SCIENTIFIC AMERICAN SUPPLEMENT

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Equestrian statue of Erasmo Gattamelata, by Donatello, at Padua, which was removed to a place of safety

RESCUING THE ART TREASURES OF VENETIA [See page 24]

The Relation of Highways to Freight Transportation*

A Vital Problem in This Country Today

By W. A. Alsdorf[1]

THE most vital problem of the great world war is that of transportation. For months the greatest menace of Allied success, the gaunt spectre that has haunted the council chambers of the leaders of the Allied cause, has been the submarine; and this because the sub-sea craft threatened the lines of transportation that must be kept open if the Allies were to be fed, clothed and provisioned, and if the men and wealth of America were to be thrown into the scale in a way to count. The breakdown in the spirit and morale of the Russian people was preceded by an almost complete paralysis of that country's transportation. Much of Germany's apparent success has been due to the fact that she has been fighting from the inside of a circle with greatly shortened lines of communication and a resultant lessening of her problems of transportation. It is isolation and lack of transportation facilities that renders impotent the hundreds of thousands of trained soldiers of the Japanese Empire. The Allies have a vast preponderance of men, money and national resources; and a solution of their transportation problems which will permit them to exert their strength along the western front will enable the armies of Haig, Petain and Pershing to drive the Germans across the Rhine and end forever the Kaiser's dream of world conquest.

But the transportation problems of the war, so far as the Allies are concerned, are not all external; they do not all relate to keeping open the paths across the sea and providing ships and ships and still more ships. Each allied country has its own internal transportation problem, and of these problems that of America is not the least. Our country like its Capital City is noted for its magnificent distances, and its transportation problems present many aspects that are absent in a country like England, where every haul is, comparatively speaking, a short haul.

Whatever may be our problems, however, we are coming to realize more and more that efficiency in transportation, both across the seas and within our own borders, is and will be the measure of our success in winning the war. Today the lack of ships is the greatest handicap to our plans for defeating Germany. For tomorrow a dual danger is appearing upon the horizon, the breaking down of our railway facilities and our lack of preparation in the past, now so plainly perceived, to supplement our railroads by the construction of a complete and usable system of highways. Either the paralysis of railway transportation or our failure before another winter to remedy our situation with respect to highways will constitute a broken link in the chain of national effort for victory.

War conditions have so increased the transportation needs of the Federal Government that the available railroad transportation facilities are insufficient to meet the present combined demand of the Government and private enterprise. Inadequate transportation facilities have already become a strong limiting factor in general business, thereby decreasing both the earning power and industrial efficiency of our citizenship. The railroads of the country admit their inability to cope with the dual demands being made upon them, and a further decrease of transportation service may bring not only suffering upon the people, but also a possible catastrophe to the nation by reason of its helplessness to transport those things absolutely necessary for use upon the farm, in the mill, the factory, the store and the home.

An abnormal transportation problem confronts the country. In normal times about one billion three hundred and twenty million tons of freight are handled annually, yielding about two billion dollars in gross revenue. Last year this amount was increased about 41 per cent and this year about 11.9 per cent will be added to last year's figures. Our domestic trade has increased about 50 per cent and our foreign trade over 100 per cent. In addition to this an unprecedented amount of government supplies is being moved to and from tide water, and in many instances handled half a dozen times from one plant to another in the process of manufacturing and finishing. Thus the reason of abnormal railroad freight congestion is made apparent.

The President says: "The course of trade shall be as unhampered as it is possible to make it." To what other method of transportation can we turn in the hour of our emergency to maintain trade but to the public highways. They are the only great agency we can use to supplement the transportation facilities of the railroads. Private enterprise, so essential to a healthy business condition and to the successful prosecution of the war, may within the next year be compelled to depend largely upon transportation over the public highways for its very existence. To this already breaking strain placed upon our railroads by the industrial and commercial demands is added another of even greater importance. President Wilson has said that "Upon the farms of the country in a large measure rests the fate of the war and the fate of the nation. May the nation not count upon them to omit no step that will bring about the most effectual cooperation in the sale and distribution of their products." The world faces a food shortage. It faces unprecedented prices for foodstuffs. The American farmer has been appealed to from every source to increase his crops that the world may be supplied with food and that the price may be kept down. Yet, not a bushel of grain nor a pound of meat is grown in this country that does not at some time in its journey, from the point of production to the point of ultimate consumption, pass over some of our American highways on its way to the railroads. Thus we see that the business of the nation is depending largely upon a single unit of transportation now bending almost to a breaking point, and the public highways as the only auxiliary means of transportation have suddenly by reason of war conditions grown from a position of economic usefulness only, until they have become a vital war necessity and the very foundation for the superstructure of our national prosperity, stability and efficiency.

As we were unprepared in shipping and in railway requirements, in munitions and war supplies, so were we also unprepared in the physical condition of our highways for this sudden transformation of trade. But as we have met the other and greater problems so can we meet and solve this one.

Today the call is for our brains as well as our blood for our country. American business men have answered their country's call in a manner never known in the past. A few years ago it would have been impossible to gather together at Washington the greatest business minds in the country for the purpose of running the affairs of the nation, yet today we have the services of our best railway executives, our best steel men, our best engineers, our best economists, all working hard and making history. They are putting their heads together and evolving methods for increased efficiency and getting things done that are astounding. All over the country business men have turned their thoughts in a common direction to do those things necessary to prosecute the war successfully and to keep the essential industries of the nation going at top speed. This is the real job of those who stay at home and thus it seems peculiarly expedient to present to you today this subject, and ask for it your most careful consideration.

A partial solution of the transportation problems is indicated in a bulletin issued by a Committee of the National Council of Defense containing the following statement: "The agricultural, commercial and industrial world must turn to the mutual use of motor trucks to relieve freight congestion, and apply the same high standards of organizations, efficiency and development to motor truck service as now characterizes modern industrial plants." The usefulness and pertinency of this suggestion may be the better realized when we stop to think that fully 60 per cent of the present freight congestion at terminals is due to small merchandise passing from the manufacturers to the jobbers and thence to the retailers, involving in nearly all instances a haulage within the capabilities of the motor truck.

Thoroughly organized freight and express service might be adopted by those communities that are suffering from freight congestion, utilizing the motor truck for the collection of raw materials and the delivery of finished products within a radius of 100 to 150 miles. In fact this is the immediate purpose to which the recently appointed Highways Transport Committee of the National Council of Defense are giving their attention. The motor truck is not today a vehicle of the cities and towns, but its use is as general as the distribution of mail; its ramifications as broad as those of the rural telephone and its use takes in every road, improved or otherwise, in the country. Intercity haulage of commodities is not an experiment. The practicability has been established in practice and when the schedule provides for the truck carrying a capacity load on its return trip such haulage has proven a profitable investment. Coordination of manufacturers in utilizing their trucks to haul in both directions is necessary for economy and profit. The collection and distribution of agricultural products are also necessary factors in the problem. The establishment of a mutual freight and express service will not be confined alone to manufacturers, for the plan is equally practicable for community uses and to supply cities and towns dependent upon outside sources for food supplies. The use of fleets of motor trucks by merchants and municipal authorities will facilitate the distribution of supplies to sections unable to obtain commodities through regular channels. Such a service will satisfactorily bridge the gap between the producer and consumer and encourage the development of home markets for home products. In many parts of our own and other states, motor trucks have been used to market farm products direct. It has been found that such shipments are more rapid than railway. Freight congestion and shortage of cars not only this year but in the past have caused tremendous waste at points of production as well as at terminals. To reach close-by markets the motor truck actually beats the railroads, both as to cost and time, thus serving the producer better than has ever been done before. Very recently the Federal postal authorities have taken up the question of establishing a heavy parcel post service between Columbus and Zanesville, a distance of 57 miles over a highly improved road, with a view of finding out a basis of cost upon such deliveries. This truck service supplemented by the present large volume of vehicular traffic would enable the entire country to become self-supporting and would make possible the utilization of a very large part of our railway facilities by the Federal Government, if our public highways were in a usable condition.

Out of some two million miles of roads, or rights of way, in this country we have today, at the most optimistic estimate, some 200,000 miles which have received any attention or improvement of any character, and to the best of my knowledge not over 40,000 miles of roads have been actually constructed with some degree of permanency and maintained in such a fashion that they could be used as an auxiliary transportation system. And, even this available road mileage is limited in its usefulness by the fact that it has been constructed under no central directing intelligence, that it is the result of local endeavors at widely sparated points and does not in any degree link up to form what can be referred to as as a "Road System"—roads which lead from some place to some place.

The President in his war message to the American people said: "This is our opportunity to demonstrate the efficiency of a great democracy and we shall not fall short of it!"

To which we might observe, that the efficiency of this democracy, the efficiency of any political unit, depends largely upon the degree of national unity of purpose and the degree of centralized directing authority exercised over great national enterprises. The highest efficiency in a factory cannot be reached under a plan which contemplatees each man going ahead upon his own initiative, undertaking that which pleases him best, and doing it in a way which suits his individual taste. Neither can the greatest efficiency be reached in road building under a plan which makes the ultimate completion of the whole dependent upon each minor local unit doing its share in its own way with its own limited ability and funds and from its own standpoint.

It would, therefore, appear that present methods for improvement of public highways are antiquated and not suited for present needs, and that by reason of the serious conditions affecting transportation facilities today and the imminent dangers to the nation's prosperity and safety, it is imperative to immediately readjust the methods of highway improvement to meet the requirements of the nation. To this end Congress should be urged to declare road building a war necessity and to take steps to formulate a definite plan, that will nationalize road building throughout the country. Such a plan should coordinate the road building activities of every unit of government. The needs of the Federal Government might necessitate a designation of certain main roads that are of military or strategic importance, to be national roads. It should provide that the links and gaps upon these roads should be improved at once with all the resources and funds available for that purpose by the Federal Government. If needed it should provide that bridges and culverts be strengthened to

*From the *Journal of the Cleveland Engineering Society*, March 1918, page 285.

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pass heavy artillery or other exceptional loads. It might further designate as a second class those roads of primary importance to the industrial centers of the various states. The Federal Government and state authority should alone be responsible for their improvement, which should not in any way be hampered by the ability or desire of the lesser units of government.

The third class for improvement would be those roads connecting up our country seat towns upon which largely rests the burden of handling the agricultural products of the country. While these should be improved very largely at local expense, yet it would seem that the great need of the present would justify both the Federal and State Governments sharing a part of the investment.

A fourth class would be those roads of local significance whose improvement should be guided in a manner to be supplementary to the other system. Such a centralizing plan would necessarily mean the changing of the laws of many states of the Union, as well as Federal law affecting it. Present limitations for issuing bonds and making levies would have to be changed. Transportation of road building materials would no doubt be guided by certain priority rulings of the Federal authorities that would be in line with the improvement of the various classes determined to receive it. The financing of the various projects would no doubt receive consideration by the Federal Reserve Bank System and its member banks throughout the country. The labor problem would receive consideration and no doubt its solution could be brought about through cooperative State and Federal authority. In fact the Federal Government would be the guiding hand in all steps necessary to bring speedily to a state of usefulness this great highway transportation system of the nation.

By some such systematic central plan we would be able to bring about quickly a wonderful transformation in the conditions of our public highways, thus enabling them to be, what they rightfully should be, the second greatest public utility of our country. It would then be possible to relieve the congestion of the railroads, keep the mills and factories busy, collect and distribute the foodstuffs, and give a stability and mobility to the resources of America.

The relation of the highways to freight transportation will then be like that of America to her Allies, the basis of their strength and power, as well as their salvation in the hour of their peril. Build the public roads with even a small part of the gigantic energy that we are using to build and equip our shipping, or furnish supplies to our Allies, and you will equip America with a power to unfold her resources immeasurably in war, and give her an agency for expansion and trade when peace is restored, far above that of armies or navies or the mighty equipment of war.

Animal Life at the Front

By William Beebe

No stranger association ever existed than that of animal life at the front, as I was able to observe it on various sectors during the past winter. First of all, there is the rather delicate personal viewpoint, familiar to most of the poilus themselves, which ranges from lice and fleas through bluebottles to rats. After that comes the important economic phase, with our friends, the dogs and horses, and our acquaintances, the canaries and homing pigeons, playing their admirable parts. Finally there is the abstract, naturalistic consideration of the wild life which has become wonted to the *bruit* of the terrible struggle, and will find it strange when at last silence settles over those wasted deserts and tortured landscapes. I shall refer chiefly to this last aspect of wild life.

Under an intensive barrage or bombardment, almost every form of human activity ceases, in the area about the front lines. The sole exceptions are the aviators who, by their command of the three planes of space, are able to rise above effective fire from Archies, or if contour flying at low heights can, by sheer speed, avoid danger from machine guns and rifles. Considering the war zone as a whole, much the same thing is true of feral animal life, birds and bluebottles, and other creatures of flight being most in evidence. In spite of the months and years of constant noise and flames, gases and dangers, wild birds have shown an astounding disregard of these supreme efforts of mankind. They soar and volplane, they seek their food, quarrel with one another, carry on their courtship, mate and rear families in close proximity to the actual fighting and exploding shells. In fact, their numbers have increased near ruined villages, where they nest in the shattered houses, and in cathedrals still smoking from devastating bombardments. Besides this increased nesting facility, and the immunity from disturbance by man, thanks to his preoccupation with his fellow beings, there is a less pleasant reason for the great numbers of insect-eating birds, which live and thrive in this region. The terrible conditions of sanitation and the numbers of unburied dead in many of the sectors result in a plague of flies, mostly great bluebottles, and these in turn attract the birds—martins, swallows, swifts and others which find an abundance of food in these hosts of insects.

The intricacies of animal action and reaction can be traced in many ways. In one sector I observed a very great number of scavenger rats—even more than the usual hordes which tear through the dugouts, and shatter the nerves of the pickets by rustling the dried grass in No Man's Land. And correlated with this increase of rodents was an abnormal number of large birds of prey, I saw them perched on the splintered stubs of trees, on the raw ruins of farmhouses and villages, and even on an abandoned tank, which had settled in a hole stern-foremost, with the front reared high in air. A large hawk, almost as light colored as a gyrfalcon, was perched on the topmost pedal of one of the caterpillar treads, and suddenly I saw it leap into the air, fall over in a most undignified way, catch itself and fly off at full speed. A hollow sound from the interior explained the cause, a sniper having taken up his station there. The noise of his rifle in the hollow tank must have been as terrifying as it was unexpected to the hawk perched just outside.

My introduction to bird life at the front, came when I was several thousand feet up, and repassing the front line trenches. I was looking down through my glasses following the undulations, the sudden twists and salients of these inconspicuous frontiers of barbarism and civilization, when a tiny black speck crossed my field, above the pale gray of low-lying vapor. I took it at first for a trick of tired vision, until it came again from the opposite direction. A quick twist of finger and thumb and the zigzag trenches blurred from focus and the black spot became distinct and vibrant—a skylark hovering at an amazing height, doubtless in full song. I looked at the compass and down through the crossed hair lines, and realized that it was a German skylark and that I was over temporary Bocheland.

Few aeroplane pilots or observers recall memories of engine trouble without a shudder, and yet twice I have had most remarkable experiences as a result of missing cylinders. The last time I was forced to land in an isolated district of northern France, and was salvaged by an officer whom I had last met in the hinterland of India. He motored me on my way toward the front and promised several surprises, the first of which was fulfilled almost at once. We stopped beyond a little bridge and walked a short distance into a French forest. Within a few minutes we heard a wolf howl, a sound which in modern Europe I had supposed was confined to the wilds of Russia. In several places in France wolves have since been reported, hunger driving them down from the more isolated regions where their race still survives.

Near Verdun, late one evening, when I was looking over the ghastly desert back of Douamont—a land of slime-filled shell holes, with half-fallen wooden crosses and the flapping remains of old camouflage as the only relief from mud, I was surprised to see a fox creep across a line of irregular mounds which once had been a cozy, picturesque village.

Back of the lines, in the most miserable marshes and swamps, herons stood disconsolate, mudhens crept about, and ducks slithered down into the grassy water. In the center of the fields, small covies of patridges cowered, or fed timorously; blackbirds called softly in the evening, between the boom and the kr-rump of distant guns. Whether seen from train, motor or aeroplane, the dominant bird-life of France, at least in winter seemed to be the flocks of rooks and crows, feeding in the fields or drifting in their curious massed flight through the air. Rooks were the birds most frequently encountered in mid-air. In late afternoon, I once found myself among fifteen or twenty of these birds at a height of forty-five hundred feet. I had not seen them until I was close, and they too were evidently surprised, as before I could dip and pass beneath and beyond them, several had been thrown wholly out of control by the suction of the propeller blades rolling helplessly over and over, and only catching themselves when beyond the vibrations of this aerial maelstrom. There was certainly opportunity for gossip in one rookery of France that night, concerning the adventure which befell a mile above the earth.

The trim magpies of France, singly or in pairs, will always be associated with the ruined villages, the long straight roads lined with poplars, and the winter tilling of the fields. Their nests were difficult to distinguish from the bunches of misletoe swung among the leafless branches, and they too were making themselves at home among the fresh ruins of farmhouses and erstwhile village streets.

I once lay flat in a trench looking up at a small wood, where a steady stream of machine gun bullets was hissing past, showering down a continuous rain of twigs, splinters and occasionally sprigs of misletoe. Every five minutes a shell of some kind or another would rip off a branch, or bury itself in the earth; if a dud, to die with a single thud, or if fulfilling its destiny to explode and send a shower of roots, mold and splinters in every direction. If twenty sportsmen were seated in this small patch of woodland, shooting continuously and regardless of direction, the noise and disturbance could not have been greater, yet a party of three great titmice, a small woodpecker, a jay and a pair of wood pigeons came now and then within my field of vision, on the alert obviously disturbed, but showing no inclination to cease feeding and escape at headlong speed, which would have been the instant reaction of any birds unused to this volcanic part of the world.

In the Tuilieres Gardens in Paris, at midnight, at the height of the January raid, I saw groups of wood pigeons sleeping peacefully through the excitement—heedless of the noise of planes and star-shells, shrapnel and mitrailleuse, sirens and bugles.

One of many interesting instances of birds close to the lines is that of the swans at Ypres. A chateau still nearer the Boche lines had been under intermittent fire literally for years. The building itself gradually became a mass of ruins, the woods were torn and splintered and the great moat became little more than a half-filled ditch. Yet a pair of swans continued to live here month after month, through gas shells which made masks absolutely necessary for a half hour at a time. Every soldier hereabouts knew of the birds, and the Anzacs especially never tired of feeding them. Their ultimate fate I never learned, but the marvel of their continued existence under such terrible conditions of gas, shrapnel and shell fragments will forever remain.

One of my last memories of the trenches had to do with a wild bird. Early one morning I was leaning against the soft mud of the back of the trench looking up at the strange sight of blue sky overhead, with half a dozen Nieuports and Spads swooping and rolling as if they felt the exhilaration of the crisp air in their canvas skins and spruce skeletons. Three poilus were near me, idly looking up, when suddenly all ducked and doubled over, then looked sheepishly at me and laughed. I saw the cause, but did not know enough, or rather stupidly knew too much, to follow suit. A house sparrow, or as we call it, an English sparrow, had flown up and over the parapet and alighted on the heaped sandbags piled at the back, and its sudden appearance was a close imitation of a hand-thrown grenade. I had had little experience with such missiles, but from my life work, I reacted instantly to the sight of the bird and did not give it a second glance. So there was no incentive to flinch as I should certainly have done, had I known what it might have been. To the soldiers, experienced in this sunken warfare, the appearance of any object from that direction meant death; but to me it was only a male house sparrow, still in the veiled winter plumage. —*Bulletin* of the New York Zoological Society.

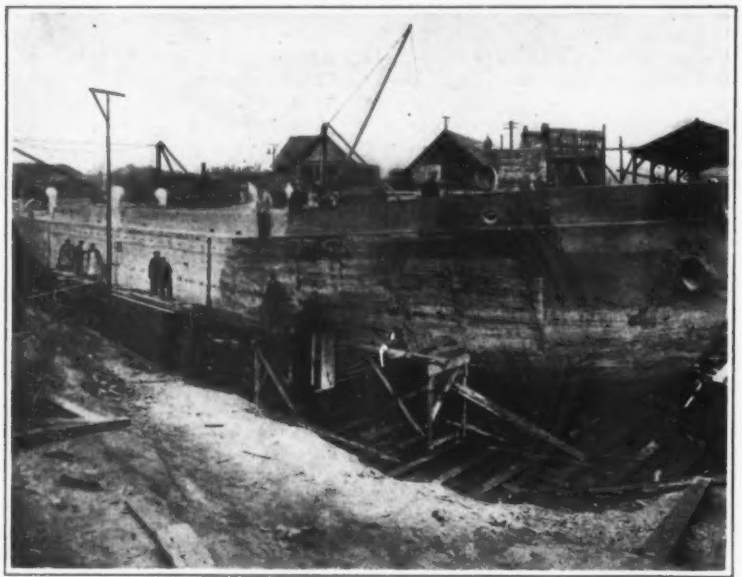
Electricity in Agriculture

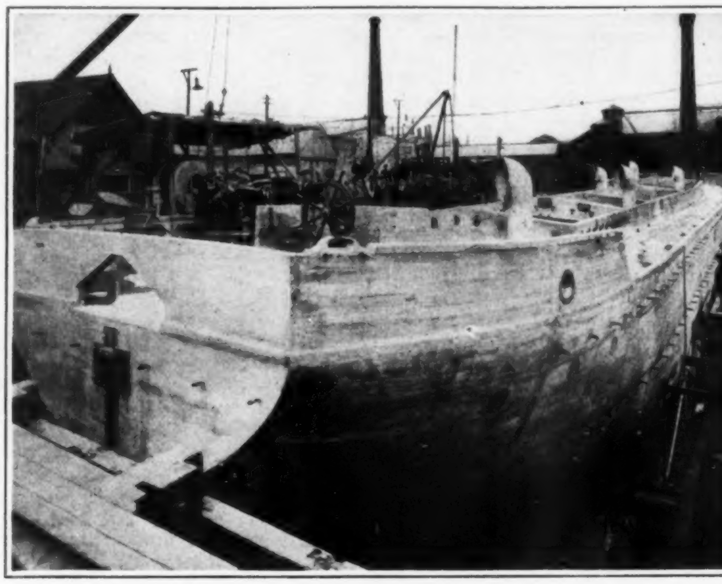
In view of the fact that practically every country in the world is seeking every possible means for increasing its agricultural crops it is interesting to note that an English company is bringing out an electrical system of stimulation, which is described as follows:

The method employed is to stretch over the field to be treated a network of extremely fine wires; the wire is so fine as to be hardly visible, even when quite close to it. The wires are spaced 12 yards apart, and are suspended 18 feet above the ground from larch poles; this network is carefully insulated from the posts, only 40 to 50 posts being required for 100 acres. A positive continuous current of electricity is supplied to the wires at extremely high pressure (60,000 to 100,000 volts), but the quantity of current used is quite small, 10 to 30 watts per acre being sufficient. This current can be generated by a 2-horse-power oil engine, such as is widely used for farm purposes, and all that is wanted is a small dynamo belt-driven from the engine. The current is used for only a few hours each day, and it is explained that it "leaks or fizzles off through the air to the plants beneath."

Estimates of cost of installation and operation are given, with comparison with the results. It is stated that an oufit for a 100-acre lot, installed, would cost about $2,200, assuming the farmer already has a suitable engine. The upkeep, including depreciation at 10 per cent, fuel, maintenance and labor is estimated at $400. Against this the gross increased crop of wheat, is estimated at $2,000, leaving a net profit of over $1,400.

This makes a decidedly attractive showing, but, although there seems to be little doubt that many kinds of crops can be successfully stimulated by electricity, the subject is far from being well understood; and it would be well for those interested in the subject to refer to an article on "The Electroculture of Crops" which appeared in the Scientific American Supplement of June 8, No. 2214, which gives an excellent review of the subject.





Photos by Western Newspaper Union

General view of a concrete vessel ready for launching. Smoothing down the outer surface

The ironwork for mounting rudder and propeller cast in place. Also bolts to attach fender timbers

The Concrete Ship Problem

A Review of Facts Developed in Recent Discussions

The concrete ship has been accepted with enthusiasm by the general public, partly from a recognition of the pressing necessity for increasing our transportation facilities, and partly as a result of the glowing statements of various self-constituted experts, and the propaganda of the cement manufacturers; the better qualified authorities on shipping matters, however, recognize the concrete ship as a war measure, but withhold their decision as to its desirability, and practicability in normal times.

It is true that one concrete vessel, built in this country has made a single short voyage successfully, and this is heralded as a conclusive proof that a radical revolution in the art of shipbuilding has been accomplished, but a very much more extended experience will be necessary before any conclusive deductions can be drawn, and many more ships of varying design must be built before the proper methods of applying this material, which possesses many peculiarities not yet fully understood, can be determined. There is one feature of the "Faith," the large concrete ship recently put into service on the Pacific coast, that would seem worthy of more careful consideration, and which may be applicable to cargo ships of whatever material they may be built, and that is its simple form, largely designed on straight lines, which would greatly simplify construction, with a corresponding decrease in cost, as it would eliminate much of the complicated work of bending the frames of steel vessels and the fitting of the plating, and the patchwork construction with specially hewn timbers in wooden ships. From the accounts published of the trials of the "Faith" and of its first voyage, it may be accepted that she is seaworthy in form, and easy to drive; and if these facts prove true, it would seem that it is possible to adopt the straight line construction in sections to many other vessels that are now proposed with a considerable saving of time and expense, both of which items are of the first importance in existing conditions.

Looking at the proposition broadly, and without prejudice, practically nothing is known with certainty about concrete ships, the action of sea water on reinforced concrete structures is not yet fully understood, and even in buildings on land, where the problems are much simpler, and in which very wide experience has been had, new questions are arising frequently enough to demonstrate that there is still much to be learned about concrete. It is true that a large number of reinforced concrete craft have been built, and have performed satisfactorily for considerable periods, but these have all been of small size and mostly employed in comparatively quiet waters, while the ships that it is proposed to build for ocean cargo carrying are to be many times as large, and problems that are insignificant in the small craft become very complicated and serious with the increase in size. At the present time competent authorities on shipbuilding appear to agree that while it will be practical to build ships successfully up to about 250 feet in length, to meet present emergency, future construction will be limited to special classes of structures such as lightships, floating docks, landing stages, hulks and similar floating equipment.

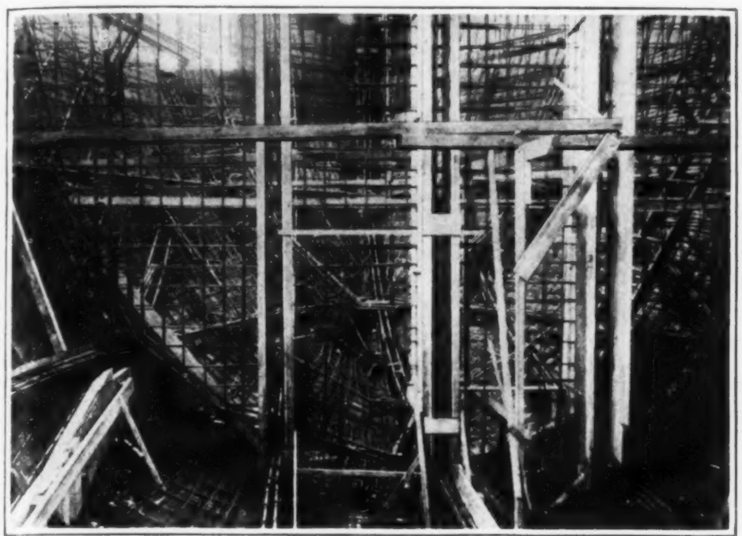
When the shipbuilders took up the problem of large concrete ships they encountered greater difficulties in their design than was anticipated, as there was no existing data to which they could refer, and they consequently called into consultation men experienced in reinforced concrete land structures, and together they have produced what is believed to be practical designs; but even so factors of safety had to be adopted which it is believed will be considerably reduced in the light of actual experience. At present a ferro-concrete ship requires about 42½ per cent as much steel as an entire steel ship, and although this shows by no means as great a saving in steel as the public has been led to suppose, still, the material used is of a much simpler form, and much more rapidly turned out than that required for an all steel vessel. On the other hand, the waste is less than 2 per cent, while in an all steel ship it amounts to about 10 per cent.

Interior side of a concrete ship showing moulded frames and longitudinal stringers

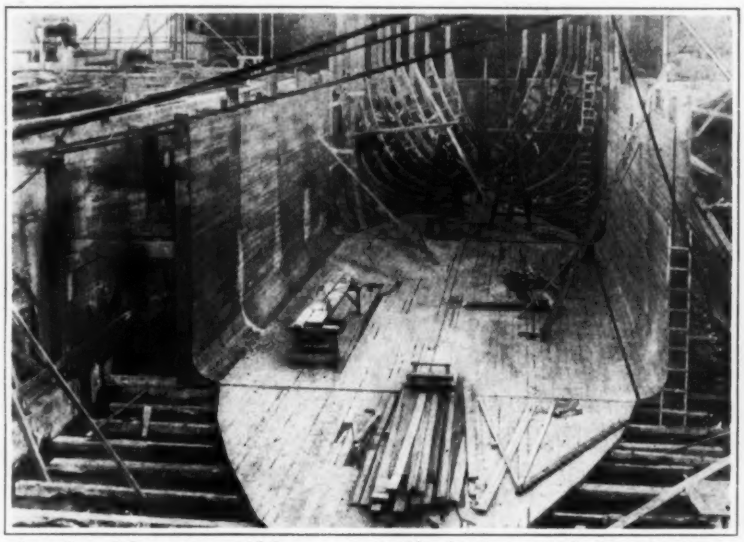
The question of cost of large ships has been much debated, but as yet there are no reliable data on the subject. Most of the estimates, which are quite favorable to the concrete ship as compared with steel, have been based on experience with vessels of about 1,000 tons, but the figures for these do not hold for ships of from 3,000 to 6,000 tons. It is stated that the equipment for a yard building concrete ships would cost only one-sixth of one for building in steel; and the greater part of the labor employed in building concrete ships may be unskilled, but there are many other items which can only be estimated in a general way. There are, however, in this connection factors that require careful consideration in comparison with steel ships, and the principal of these are carrying capacity and operating expenses. The concrete ship, as at present proportioned is considerably heavier than a steel ship, and it is estimated that the carrying capacity of a concrete ship would be about 18 per cent less cargo by weight for a vessel of about 4,000 tons, or from 35 to 40 per cent less for a 1,000-ton vessel. It is also estimated that the increased displacement resulting from the greater weight of the hull would require 12½ per cent more power to drive it at the same speed as a vessel of corresponding size built of steel. As an offset for this a somewhat lower cost for repairs and upkeep may be cited. According to recent estimates a concrete ship costs about 70 per cent of that of a steel vessel; but to put concrete on an equality with steel in normal times it is thought that the concrete ship must be built for at least half the cost of steel. Undoubtedly the present cost of construction, as estimated, will be considerably lessened as further knowledge and experience is gained, but it is considered doubtful if it can be brought to the figures necessary for successful competition. In any case low cost can be attained only where a number of ships are built from the same molds. If only a single vessel is to be built the large amount of material and labor required for the molds would make the cost very high, particularly at present, especially as a large amount of skilled labor is necessary for this work.

An extremely critical element in the construction of reinforced ships is the mixing and placing of the concrete, and for this expert supervision is necessary at every step, for slight mistakes or carelessness can easily cause disastrous results.

There has been considerable discussion as to the watertightness of concrete vessels, for it is known that all concrete is more or less porous; but experience with tanks on land have shown that, although there may be some seepage at first, in the course of time the pores become filled; and in any case, if the concrete material is of the best quality and is properly put in place, the leakage will not materially exceed what may be expected in the average wooden vessel. For these reasons it is not thought that any special waterproofing processes will be necessary, especially as it would appear that no known process of waterproofing can be relied on to absolutely exclude water under all conditions. There is, however, one serious point of uncertainty in this connection, and that is the effect of cracks that may result from varying stresses to which the concrete covering of a vessel may be subjected. While concrete possesses considerable strength in compression, its tensile strength may be considered nil, and if cracks develop the constantly varying strains to which a ship is subjected in a seaway may cause friction at the cracks that would



Steel reinforcing bars that give strength to a concrete ship



A portion of the outer mould for a concrete ship showing method of construction

enlarge them into dangerous fissues. This is one of the obscure questions that can be answered only by practical experience.

In case of repair and anticipated low cost of maintenance in many directions it is expected that the concrete ship will compare very favorably with either wood or steel construction; and other good points of the concrete ship that may be cited are greatly reduced vibration and superior insulating qualities that would make a concrete ship superior to steel, both for passengers and for many kinds of cargoes in tropical climates.

From the above general review of the situation it may be gathered that, although the reinforced concrete ship promises to be a desirable addition to our transportation facilities in the present emergency, it is by no means the simple proposition that it has been represented in many quarters, and that its successful development calls for the solution of many important problems.

The vessel shown in the accompanying illustrations are of a craft recently built in England, having a displacement of 900 tons, and a dead weight carrying capacity of 400 to 500 tons.

Irrigation In Mesopotamia

THE military conquest of the great delta of the Euphrates and Tigris has been speedily followed by the putting in hand of irrigation works, which in their main features follow the scheme prepared by Sir William Willcocks for the Ottoman Government in the years preceding the war, and the first section of which, the Hindia barrage, was the subject of a contract made in 1911 with Sir John Jackson (Limited) and was completed in December, 1913. The intention of constructing various subsidiary works was frustrated by the outbreak of war, but no time has been lost since the possession of the delta was gained in improving the irrigation, and, indeed, some of the works were put in hand before the enemy had been expelled from this territory.

FAILURE UNDER TURKISH RULE

Irrigation questions have always received attention in Mesopotamia, and the early part of the Christian era was distinguished for important canal work which irrigated the country east and west of the Tigris. The ravages of war as well as neglect resulted in the destruction of many of these old works, and at one time the Euphrates had dwindled to insignificant proportions, while the junction of the Euphrates and Tigris, which for many centuries was at Kurna, is now near Basra. Under Turkish rule more than one attempt was made to carry out irrigation works. It is now about 45 years ago that work on a barrage across the Saklawia branch of the Euphrates was put in hand, but it had the disappointing result, owing to miscalculations of engineering factors, of diverting the main stream into the Hindia branch and leaving the Hilleh channel practically dry. To provide a remedy for this condition of affairs the Ottoman Government endeavored, by the construction of a weir across the Hindia branch at a point above the junction of the two streams, to refill the Hilleh channel. This project failed, partly by reason of lack of funds to carry out subsidiary works, and partly owing to the silting up of the Hilleh channel; and the only outcome of the work was that a large area of country was left waterless, except during the period of heavy floods, when inundation was the rule rather than the exception.

THE WILLCOCKS SCHEME

It was finally decided that Sir William Willcocks, who then occupied the position of adviser to the Ottoman Ministry of Public Works, should report on the situation, and all that has since been done is the result of the extensive surveys which were then made. The river delta comprises an area of some 12,000,000 acres, of which two-thirds is desert and one-third fresh-water swamp. The rainfall throughout this region averages about 8 inches a year. The rivers are in flood during the spring months, when the flow in the Euphrates is estimated at 120,000 cubic feet per second and in the Tigris at 180,000 cubic feet; and Sir William Willcocks reported that it should be possible, even without new reservoirs, to grow winter crops upon an area of 6,000,000 acres and to obtain summer crops from half that acreage. The first work undertaken under the new régime was the repair of the old Hindia barrage, as well as the making of provision for carrying off the surplus flood water of the Euphrates. The important part of the scheme then authorized was, however, the construction of the new Hindia barrage across a new channel excavated parallel to the main stream for a length of 750 meters with a breadth of 248 meters. The new barrage, with the lock, extends across the whole width of the new channel, and a subsidiary dam with lock was also provided, 50 meters below the main dam. A diversion of the Hilleh branch was made and fitted with controlling sluice gates as well as a navigation lock, and the old channel of the Euphrates was closed by an earth dam.

REPAIR OF CANAL SYSTEM

It was intended to construct two barrages on the Tigris, one of which would have been near the ancient Nimrod's dam; but the whole of the reclamation work was suspended on the outbreak of war, and little or no advantage has been derived until now from the completion of the Hindia barrage, owing to the absence of the necessary branch canals, some of which were to have been provided by the repair of the old system, which had fallen into disuse, while others were to have been new constructions. Although the estimated acreage which has now been put under cultivation falls far short of the figures mentioned in Sir William Willcocks's report, it is satisfactory to learn that nearly 100 of the old canals on the Hilleh branch have been repaired; and Mr. Edmund Candler in a recent dispatch from Mesopotamia states that 300,000 acres have been brought under cultivation, and that there is every expectation of a bumper harvest. It is mainly below the barrage that repair and construction of the canals has been carried out, but the new works, which have engaged the services of about 14,000 Arabs, have enabled land to be cultivated above the barrage as well as down stream. The preservation of the country from the effect of floods and the harnessing of the water available is naturally the first work which has been undertaken, and it is not surprising that the Arabs, who stand to gain most by what is being done, have applied themselves cheerfully to the task of excavation. They are already beginning to reap the benefit of having prevented the destruction of the Hindia barrage by the retreating Turks.

To have carried out this canal repair and construction while war is in progress is a somewhat remarkable achievement, and the fact that it has been possible suggests that serious consideration may perhaps be given at an early date to the construction of the two barrages on the Tigris included in the Willcocks scheme, which, with auxiliary works, are estimated to cost about £6,000,000,000.—Engineering Supplement of the *London Times*.

The Bird Cult of Easter Island

IN the issue of *Folk-lore* for December last Mrs. Scoresby Routledge gives a singularly interesting account of the bird cult of Easter Island. The sacred bird is the sooty tern (*Sterna fuliginosa*) and the valued privilege of securing the first egg is a matter of competition between members of the Mata-toa group, the right to become a competitor being acquired only by supernatural agency. The selection is made through a dream vouchsafed to a divinely gifted individual, the Iviatua. The candidate on selection takes a new name, and the bird-name thus conferred was given to the year in which victory was achieved, thus forming an easily remembered system of chronology. It is also significant that this bird cult is connected with the statues for which the island is famous.

The bird-man used to spend the whole of his official year on the mountain in which the monoliths were quarried; the bird initiation of children was also performed in connection with the statues, and the ring design on the back of the images was reproduced at the ceremony on the children's backs. There seems reason to believe, says the writer, that the people who originally celebrated the bird cult included in it reverence for the statues. The ancestors of the present inhabitants were, therefore, either the makers of the monoliths of Easter Island, or, if the bird worshippers represent a more recent migration, the old religion of the images was blended into, and perpetuated by, the more recent culture.

The conclusions of Mrs. Scoresby Routledge have been extended by a second paper in the same issue of *Folk-lore* by Mr. Henry Balfour on the ethnological affinities of the natives of Easter Island. He arrives at the conclusion that the island culture is composite, and exhibits traces of fusion of at least two stocks. The first was a Melanesian migration, which introduced the practice of distending the ear-lobe, a characteristic style in art, certain special types of stone implements, and the cult of the frigate-bird, which was designed as a magical method of increasing the food supply. This Melanesian culture was submerged by a wave of Polynesian immigrants, to whom is due a new bird cult, aiming at increasing in a like magical way the supply of birds and eggs.

This culture seems to be very closely allied to that of the Solomon Islands, and "it seems likely that the symbolism of many of the ideographic signs employed in the Easter Island script may be explained by a study on the spot of closely similar designs still used in the Solomon Islands, the symbolic significance of which might be ascertained before it is too late." Thus a survey of the materials collected by Mr. and Mrs. Scoresby Routledge, interpreted by the wide ethnographical knowledge of Mr. Henry Balfour, seems to bring us at last within reach of a solution of the mystery of Easter Island. It may be confidently hoped that the clues suggested by him will be speedily followed by some careful local anthropologist.—*Nature*.

Gravitation—II*

And the Principle of Relativity

By A. S. Eddington, F.R.S.

[Concluded from Scientific American Supplement, No. 2218, Page 3, July 6, 1918]

We have to admit, then, that a world-line can be bent by the proximity of other world-lines. It can also be bent, as you see, by the proximity of my thumb. The suggestion arises, May not the two modes of bending be essentially the same? The bending by my thumb (a mathematical transformation of space and time), is in a sense spurious; the world-line is pursuing a course which is straight relative to the *original* material. Or we may perhaps best put it this way—the world-line still continues to take the shortest path between two points, only it reckons distance according to the length that would be occupied in the unstretched state of the bladder. It is suggested that the deflection of a world-line by gravitation is of the same nature; from each world-line a state of distortion radiates, as if from a badly puckered seam, and any other world-line takes the shortest course through this distorted region, which would immediately become straight if the strain could be undone. The same rule—of shortest distance as measured in the undistorted state—is to hold in all cases. This is a mode of reasoning which has often been fruitful in scientific generalizations. A magnetic needle turns towards the end of a bar-magnet; it also turns towards a spot near the pole of the earth; hence the suggestion that the earth is a magnet. We assume the essential identity of the two modes of deflecting the needle. It is a daring step to apply the analogy and assume the essential identity of the two ways of deflecting world-lines; but at any rate we shall make this assumption and see what comes of it.

You will see that according to this view the earth moves in a curved orbit, not because the sun exerts any direct pull, but because the earth is trying to find the shortest way through a space and time which have been tangled up by an influence radiating from the sun. We can continue to describe this indirect influence of the sun on the earth's motion as a "force"; but, assuming that it makes itself felt as a modification or strain of space and time, we are able to bring the discussion of the laws of this force into line with the discussion of the laws of space and time, *i. e.*, the laws of geometry. Needless to say, we could not determine a physical law like the law of gravitation by geometrical reasoning without making some assumption.

I am afraid that to talk of a force as being a distortion of space and time must at first appear to you hopeless jargon. But it must be remembered first that we are not concerned with any metaphysical space and time. We mean by space and time simply a scaffolding that we construct as the result of our measures; and if anything queer happens to our measuring apparatus, the scaffolding may easily go crooked. Taking our everyday conception of space, we should say that this room is at rest; we have been told that it is being carried round the earth once a day, but in practical life we never pay any attention to that. The space that we naturally use is thus different from, and it is not difficult to show that it is distorted as compared with, the more fundamental astronomical space in which this room is traveling at a great velocity. So our scaffolding is crooked. But, it may be asked, in what way can this distortion of our space-scaffolding be regarded as a force? The answer is quite simple. We perceive it as a force, and that is the only way in which we do perceive it. We do not perceive that this room is being carried round by the earth's rotation, but we perceive a certain force—the earth's centrifugal force. It is rather difficult to demonstrate this force, because gravitation predominates overwhelmingly; but if gravity were annihilated we should have to be tied down to the floor to prevent our flying up to the ceiling, and we should certainly feel ourselves pulled by a very vigorous centrifugal force. That is our only perception of the crookedness of our scaffolding.

We often call the centrifugal force an "unreal" force, meaning that it arises simply from a transformation of the framework of reference. Can we feel confident that gravitation is in any sense more "real?" In effect they are so much alike that even in scientific work we speak of them in one breath. What is called the value of gravity in London, 981.17 cm./sec.^{2}, is really made up partly of the true attraction of the earth and partly of the centrifugal force. It is not considered worth while to make any distinction. Surely, then, it is not a great stretch of the imagination to regard gravitation as of the same nature as centrifugal force, being merely our perception of the crookedness of the scaffolding chosen.

*Discourse delivered at the Royal Institution, reported in *Nature*.

If gravity and centrifugal force are manifestations of the same underlying condition, it must be possible to reduce them to the same laws; but we must express the laws in a manner which will render them comparable. There is a convenient form of Newton's law, which was given by Laplace and is well known to mathematicians, which describes how the intensity at any point is related to the intensity at surrounding points—or, according to our interpretation, how the distortion of space at any point fits on to the distortion at surrounding points. It is evidently an attempt to express the general laws of the strains in space and time which occur in Nature. If we are correct in our assumption that gravitation involves *nothing more* than strain of space-time,[1] so that its law expresses merely the relation between adjacent strains which holds by some natural necessity, clearly the strains which give the centrifugal force must obey the same general law. Here a very interesting point arises. We cannot reconcile the Newtonian law of gravitation with this condition. Newton's law and the law of centrifugal force are contradictory.

To put the matter another way, if we determine the strains by Newton's law, we get results closely agreeing with observation, provided Minkowski's space-time is used; but if we avail ourselves of our right to use a transformed space-time, the results no longer agree with observation. That means that Newton's law involves something which is not fully represented by strains, and so does not agree with our assumption. We must abandon either our assumption, or the famous law which has been accepted for more than 200 years, and find a new law of gravitation which will fall in with our requirements.

This amended law has been found by Einstein. It appears to be the only possible law that meets our requirements, and in the limited applications which come under practical observation is sufficiently close to the old law that has served so well. In practical applications the two laws are indistinguishable, except for one or two crucial phenomena to which reference will be made later. But in gravitational fields far stronger than any of which we have experience, and for bodies moving with velocities much greater than those of the planets, the difference would be considerable.

This idea of the distortion of space as the *modus operandi* of gravitation has led to a practical result—a new law of gravitation. It is not brought in as a hypothetical explanation of gravitation; if Einstein's theory is true, it is simply of the nature of an experimental fact.

If we draw a circle on a sheet of paper and measure the ratio of the circumference to the diameter, the result gives, if the experiment is performed accurately enough, the well-known number π, which has been calculated to 707 places of decimals. Now place a heavy particle at or near the center and repeat the experiment; the ratio will be not exactly equal to π, but a little less. The experiment has not been performed, and is not likely to be performed, because the difference to be looked for is so small; but, if Einstein's theory is correct, that must be the result. The space around the heavy particle does not obey ordinary geometry; it is non-Euclidean. The change in its properties is not metaphysical, but something which, with sufficient care could be measured. You can keep to Euclidean space if you like, and say that the measuring-rod has contracted or expanded according as it is placed radially or transversely to the gravitational force. That is all very well if the effect is small, but in a very intense gravitational field it would lead to ridiculous results like those we noticed in connection with the Michalson-Morley experiment—everything expanding or contracting as it changed position, and no one aware of any change going on. I think we have learnt our lesson that it is better to be content with the space of experience, whether it turns out to be Euclidean or not, and to leave to the mathematician the transformation of the phenomena into a space with more ideal properties.

This consequence of the new law of gravitation, though theoretically observable, is not likely to be put to any practical test either now or in the immediate future. But there are other consequences which just come within the range of refined observation, and so give an immediate practical importance to the new theory, which has indeed scored one very striking success. If we could isolate the sun and a single planet, then under the Newtonian law of gravitation the planet would revolve in an ellipse, repeating the same orbit indefinitely. Under the new law this is not quite true; the orbit is nearly an ellipse, but it does not exactly close up, and in the next revolution the planet describes a new ellipse in a slightly advanced position. In other words, the elliptic orbit slowly turns round in the same direction in which the planet is moving, so that after the lapse of many centuries the orbit will point in a different direction. The rate at which the orbit turns depends on the speed of motion of the planet in its orbit, so we naturally turn to the fastest moving planets, Mercury, Venus, and the Earth, to see if the effect can be detected. Mercury moves at thirty miles a second, Venus at twenty-two, the Earth at eighteen and a half. But there is a difficulty about Venus and the Earth. Their orbits are nearly circular, and you cannot tell in which direction a circle is pointing. Mercury combines the favorable conditions of a high speed and a satisfactorily elongated orbit the direction of which at any time can be measured with considerable precision. It is found by observation that the orbit of Mercury is advancing at the rate of 574 seconds of arc a century. This is in great measure due to the attraction of the other planets, which are pulling the orbit out of shape and changing its position. The amount of this influence can be calculated very accurately, and amounts to 532 seconds per century. There is thus a difference of forty-two seconds a century unaccounted for; and this has for long been known as one of the most celebrated discordances between observation and gravitational theory in astronomy. It is thirty times greater than the probable error which we should expect from uncertainties in the observations and theory. There are other puzzling discordances, especially in connection with the motion of the moon; but the conditions in that case are more complicated, and I scarcely think they offer so direct a challenge to gravitational theory. Now Einstein's theory predicts that there will be a rotation of the orbit of Mercury additional to that produced by the action of the planets; and it predicts the exact amount—namely, that in one revolution of the planet the orbit will advance by a fraction of a revolution equal to three times the square of the ratio of the velocity of the planet to the velocity of light. We can work that out, and we find that the advance should be forty-three seconds a century—just about the amount required. Thus, whilst the Newtonian law leaves a discordance of more than forty seconds, Einstein's law agrees with observation to within a second or so.

Of course this superiority would be discounted if we could find some other application where the old Newtonian law had proved the better. But that has not happened. In all other cases the two laws agree so nearly that it has not been possible to discriminate between them by observation. The new law corrects the old where the old failed, and refrains from spoiling any agreement that already exists. The next best chance of applying the new theory is in the advance of the orbit of Mars; here Einstein's new law "gilds refined gold" by slightly improving an agreement which was already sufficiently good—a "wasteful and ridiculous excess," which is at any rate now unfavorable to the new theory.

There is another possibility of testing Einstein's theory, which it is hoped to carry out at the first opportunity. This relates to the action of gravitation on a ray of light. It is now known that electromagnetic energy possesses the property of inertia or mass, and probably the whole of the mass of ordinary matter is due to the electromagnetic energy which it contains. Light is a form of electromagnetic energy, and therefore must have mass—a conclusion which has been found true experimentally, because light falling on any object exerts a pressure just as a jet of water would. We ordinarily measure mass in pounds, and it is quite proper to speak of "a pound of light," just as we speak of a pound of tobacco. In case anyone should be thinking of going to an electric light company to buy a pound of light, I had better warn you that it is a rather expensive commodity. They usually prefer to sell it by a mysterious measure of their own, called the Board of Trade unit, and charge at least 3d. a unit. At that rate I calculate that they would let you have a pound of light for £141,615,000. Fortunately, we get

[1]The idea is that matter represents a seam or nucleus of strain, and the strains at other points link themselves on according to laws inherent in the *continum* and quite independent of the matter. The matter starts the strain, but does not *control* it as it goes outwards.

most of our light free of charge, and the sun showers down on the earth 160 tons daily. It is just as well we are not asked to pay for it.

But although light has mass, it does not follow that light has weight. Ordinarily, mass and weight are associated in a constant proportion, but whether this is so in the case of light can be settled only by experiment—by weighing light. It seems that it should be just possible to do this. If a beam of light passes an object which exerts a gravitational attraction, then, if it really has weight, it must drop a little towards the object. Its path will be bent just as the trajectory of a rifle bullet is curved owing to the weight of the bullet. The velocity of light is so great that there is only one body in the solar system powerful enough to make an appreciable bend in its path, namely, the sun. If we could see a star close up to the edge of the sun, a ray of light coming from the star would bend under its own weight, and the star would be seen slightly displaced from its true position. During a total eclipse stars have occasionally been photographed fairly close to the sun, and with care it should be possible to observe this effect. There is a magnificent opportunity next year when a total eclipse of the sun takes place right in the midst of a field of bright stars. This is the best opportunity for some generations, and it is hoped to send out expeditions to the line of totality to weigh light according to this method.

In any case, great interest must attach to an attempt to settle whether or not light has weight. But there is an additional importance, because it can be made a means of confirming or disproving Einstein's theory. On Einstein's theory light must certainly have weight, because mass and weight are viewed by it as two aspects of the same thing; but his theory predicates a deflection twice as great as we should otherwise expect. Apart from surprise, there seem to be three possible results:—(1) A deflection amounting to 1.75" at the limb of the sun, which would confirm Einstein's theory; (2) a deflection of 0.83" at the limb of the sun, which would overthrow Eintein's theory, but establish that light was subject to gravity; (3) no deflection, which would show that light, though possessing mass, has no weight, and hence that Newton's law of proportionality between mass and gravitation has broken down in another unexpected direction.

The purpose of Einstein's new theory has often been misunderstood, and it has been criticized as an attempt to explain gravitation. The theory does *not* offer any explanation of gravitation; that lies quite outside its scope, and it does not even hint at a possible mechanism. It is true that we have introduced a definite hypothesis as to the relation between gravitation and a distortion of space; but if that explains anything, it explains not gravitation, but space, *i. e.*, the scaffolding constructed from our measures. Perhaps the position reached may be made clearer by another analogy. Let us picture the particle which describes a world-line as hurdle-racer in a field thickly strewn with hurdles. The particle in passing from point to point always takes the path of least effort, crossing the fewest possible hurdles; if the hurdles are uniformly distributed, corresponding with undistorted Minkowskian space, this will, of course, be a straight line. If the field is now distorted by a mathematical transformation such as an earthquake so that the hurdles become packed in some parts and spread out in others, the path of least effort will no longer be a straight line; but it is not difficult to see that it passes over precisely the same hurdles as before, only in their new positions. The gravitational field due to a particle corresponds with a more fundamental rearrangement of the hurdles, as though someone had taken them up and replanted them according to a law which expresses the law of gravitation. Any other particle passing through this part of the field follows the guiding rule of least effort, and curves its path, if necessary, so as to jump the fewest hurdles. Now, we have usually been under the impression that when we measured distances by physical experiments we were surveying the *field*, and the results could be plotted on a map; but it is now realized that we cannot do that. The field itself has nothing to do with our measurements; all we do is to count hurdles. If the only cause of irregularity of the hurdles were earthquakes (mathematical transformations), that would not make much difference, because we could still plot our counts of hurdles consistently as distances on a map; and the map would represent the original condition of the field with the hurdles uniformly spaced. But the more far-reaching rearrangement of hurdles by the gravitational field forces us to recognize that we are dealing with counts of hurdles and not with distances; because if we plot our measures on a map they will not close up. The number of hurdles in the circumference of a circle[2] will not be π times the number in the diameter; and when we try to draw on a map a circle the circumference of which is less than π times its diameter, we get into difficulties—at least in Euclidean space. This analogy brings out the point that the theory is an explanation of the real nature of our measures rather than of gravitation. We offer no explanation why the particle always takes the path of least effort—perhaps, if we may judge by our own feelings, that is so natural as to require no explanation. More seriously, we know that in consequence of the undulatory theory of light, a ray traversing a heterogeneous medium always takes the path of least time; and one can scarcely resist a vague impression that the course of a material particle may be the ray of an undulation in five dimensions. What concerns gravitation more especially is that we have offered no explanation of the linkages by which the hurdles rearrange themselves on a definite plan when disturbed by the presence of a gravitating particle; that is a point on which a mechanical theory of gravitation ought to throw light.

From the constant of gravitation, together with the other fundamental constants of Nature—the velocity of light and the quantum of action—it is possible to form a new fundamental unit of length. This unit is 7×10^{-28} cm. It seems to be inevitable that this length must play some fundamental part in any complete interpretation of gravitation. (For example, in Osborne Reynolds's theory of matter this length appears as the mean free-path of the granules of his medium.) In recent years great progress has been made in knowledge of the excessively minute; but until we can appreciate details of structure down to the quadrillionth or quintillionth of a centimeter, the most sublime of all the forces of Nature remains outside the purview of the theories of physics.

[2] A circle would naturally be defined as a curve such that the number of hurdles (counted along the path of least effort) between any point on it and a fixed point called the center is constant. To make the vague analogy more definite, we may suppose that the hurdles are pivoted, and swing round automatically to face the jumper; he is not alowed to dodge them, *i. e.*, to introduce into his path sinuosities comparable with the lengths of the hurdles.

The Making of Monster Guns

If the contemporary dementia in favor of big things survives the tragic lessons of this war we are likely, says an engineering correspondent of the *Manchester Guardian*, to have guns with even longer range, greater accuracy, and increased projectile weight.

It will be remembered that in 1914 our flesh was made to creep with stories of leviathan guns possessed by the enemy—something to reach from Emden to London. At various times during the past two years there have been reports of intermittent long range bombardments of Dunkerque, and quite evidently these attempts and the more recent shelling of Paris are the best up-to-date achievements in practice of the monsters promised in 1914. There is scarcely room for doubt that the gun now in use is the outcome of designs and labors begun as far back as the outbreak of war, and probably long before that. The making of a great gun is a work of enormous labor and vast and particular process which may not be avoided or even greatly shortened.

The first requirements are those of constructional plant, forging furnaces, shrinking and tempering pits and gear. If gun designers go beyond the capacity of existing appliances it involves new plant. Hence it seems probable that the existing gun has been limited by the designers to a size which enables it to be treated by existing machinery. If the German monster is 85 or 90 calibers in length from breech to muzzle it would be no longer than a modern 15-inch naval gun, which is 60 calibers. Apart from the forging and shrinking plant, the lathes in which great guns are turned and bored and rifled are engineering works of almost incredible labor and cost. I believe that a great North-country firm of machine-tool makers have turned out one of these lathes in six months. I do not know if this is a record, but I do know that it was considered a highly creditable performance. A gun lathe must necessarily be twice the length of the gun to be operated upon, and I do not think that there exists anywhere a lathe which would take a very much greater job than the one now under consideration.

Given the appliances, the processes of forging, building, turning, boring, wiring, and rifling a great gun must absorb, under favorable conditions, many months. Not many years ago it was an accepted rule that one could not be made in less than 15 months—this when the 13.5 wire-wound gun was the highest accomplishment in gun construction. More modern and powerful machine-tools, together with the use of high-grade tool steel cutters, grinding attachments, and other mechanical improvements, have lessened the time; more exact and scientific subdivision of labor and betterment of material and process have certainly tended in the same direction, but still the work is one of patience and time. All modern big guns are built up, and their building is accompanied with risks and difficulties which few but the expert can understand. Cannon in which are used enormous projecting charges, as in this case, must be either wire-wound or constructed by some method which will have the same result—that of "crossing" the fiber of the steel. Thus a 12-inch gun will be wound with fully 100 miles of flat steel wire—wound on with a tensile strain of 60 tons to the square inch. This, or an equivalent process, is necessary because the charge explosion subjects the gun to both a lateral and a circumferential strain. The alternative to wiring has been sometimes used to shrinking on to the inner and secondary tubes a series of wrought steel collars, but wiring is still found preferable. There is always the difficulty of procuring flawless forgings of such size, and the least defect is fatal. It has also to be remembered that time cannot be saved by putting more labor upon the work. More men would only be in each other's way. The processes necessary are always carried out by as much skilled and unskilled labor as the job will hold.

The core of the question appears to be whether the big gun idea is a game worth the candle. I believe that the best expert artillerists regard the 13.5 gun as the most effective weapon yet designed. It is not the theoretical but constructional difficulties which seem to be as yet unsurmounted. If much larger and more powerful guns are made, heavier plant and bigger machine tools must be made. It is possible that the Germans have made some such preparations, though such a supposition would imply an enormous expenditure of precious steel and more precious labor upon very problematic purposes.

Lastly, there is the prodigious work of transporting and emplacing such guns. The laying of enormous concrete foundations, the erection of crane power, and, under modern conditions, the necessity of placing batteries of anti-aircraft guns to protect a 200-ton monster which at best can only throw an 8-inch shell and is defunct after doing it fifty or sixty times does not impress a practical engineer with its wisdom. That British armourers could make just as good, indeed much better guns, than the German monster is quite certain, but I venture to express the fervent trust that they will not try or be asked to try. From a military point of view one bombing aeroplane is worth a bettery of long-range guns, and with good luck can work more havoc in a single trip than can the monster in its entire lifetime. Monster-making appears to be an example to avoid rather than one to emulate.—*The English Mechanic.*

The National Electric Safety Code

The Bureau of Standards has recently issued Circular No. 22, entitled, "The Scope and Application of the National Electrical Safety Code."

This circular is intended to aid those to whose attention the Safety Code has been called and those who are contemplating its adoption or use in acquiring the necessary familiarity with intent and scope. The need for the Code is explained and examples of personal injuries by electricity are given, most of them avoidable by observance of the rules. The method of arrangement of the Code to promote its convenient use and the intended manner of application of the Code by engineers and inspectors are briefly explained. A short summary is also given of the provisions of each of the four principal parts of the Code.

As the code is being adopted on trial by many administrative bodies and public utility companies, it is expected that this circular will facilitate its introduction and aid in its interpretation.

This paper is now ready for distribution and those interested may obtain a copy by addressing a request to the Bureau.

New Radiographic Method

The considerable use of radiography during the war has led to a constant research for new methods. What is required in a radiographic examination of war wounds, especially as regards injury to the bones and the location of projectiles, is to employ an early and rapid examination. But as in most cases the surgical work can only be undertaken after the results shown by the radiographic plate, what is important is to reduce the time to a minimum. One of the principal methods now employed for shortening the time is the use of direct images upon paper instead of upon plates. This is brought about by improvements in the paper on one hand, and on the other by the use of a screen which considerably shortens the time of exposure. The new method not only reduces the time required to obtain the radiography, but affords a great economy, for the expense resulting from the purchase of radiographic plates is very high, and thus the use of direct radiographs on paper will cut down this item in a great degree.

Barges on their way up the Po to a place of safety

Loading objects of art on barges at Venice

Rescuing the Art Treasures of Venetia—I

From the Air Raids of the Austrians

By Commendatore Dr. Arduino Colasanti[1]

It has already been observed and duly noted that the fury of the Austrian and German armies against Italian monuments and works of art did not begin with the present war, when in 1915 the cannons of the imperial fleet shelled the Duomo of Ancona and the hydro-airplanes dropped bombs on Sant Apollinare Nuovo at Ravenna, and destroyed G. B. Tiepolo's marvelous ceiling in the Church of the Scalzi at Venice. It is a stubborn fury that has endured for centuries, and anger made up of jealousy and cowardice—jealousy of that which our enemies have not and never can have, and which is the omnipresent and ever recognizable evidence of the nobility and genius of the Italian race, so that wounding Italy in her monuments and her beauty gives to her enemies a sort of illusion of striking her in the face; cowardice, because they know that this singular beauty of ours is fragile and unable to defend itself, so that striking and wounding it is like striking a baby in the presence of its mother.

This fury has endured for centuries, unchanged, as unchangeable as the races with their affinities and instincts have remained beneath the veil of progress. In fact one's thoughts run back at once to Attila and Genseric when we read the words spoken a few months ago by General Dithfurt:

"What does it matter to us if all the masterpieces of art go to the devil? They call us barbarians? It amounts to little! We have been sufficiently bored already by this odious uproar about Rheims cathedral. Many other monuments are destined to the same fate!"

How different are these words from those which a great Italian writer, Daniello Bartoli, uttered in the seventeenth century; "For my part, I would rather make myself great by unearthing fallen cities and drawing them forth from ancient ruins than by destroying and burying those that are now flourishing."

And how different from the deed of the Vandals when, after destroying half of Rome, they stopped before the basilica of St. Peter, not out of respect for art but from religious sentiment; or from that which Plutarch narrates of Demetrius, who when attacking Rhodes wanted to save the "Talysus" of Protogenes! What a difference there is between the instinct of the Uhlan who did not touch the "Reliquary of the Thorn" because he was afraid of being struck dead, and that of Louis XIV's stern order to his artillery in 1677 not to throw bombs upon the monuments of Cambrai! What a difference between General Baron Culoz's Austrian soldiers who, in the night on June 11, 1848, broke into the Sanctuary of Monte Berico, above Vicenza, ripped Paolo Veronese's great painting "La Cena di San Gregoria Magno" into 32 pieces with their bayonets and trampled them under foot, and the soldiers of General Raffaele Cadorna, who, on September 19, 1870, before the walls of Rome, sent to Nino Bixio the peremptory order: "You are not under any circumstances to fire upon the Leonine City; you can do so on the rest of the fortifications, but *absolutely saving the monuments*."

We Italians have so much history that we often forget it, with a refinement like that of noblemen who dislike to recite in public their own titles and the glorious deeds of their ancestors. But the performances of Field Marshals Haynau and Thurn, who in June, 1849, bombarded Venice for 24 hours, hurling upon her more than 20,000 shells, many of which struck monumental churches, marvelous paintings, priceless masterpieces of art, are too recent, and the feeling of revolt aroused throughout the civilized world by the infamies methodically committed by the Germans at Ypres, Louvain, Rheims, Soissons, Arras, is too keen for Italy to permit herself not to remember this time.

Therefore, in April, 1915, when war seemed inevitable, Corrado Ricci, Director General of Antiquities and Fine Arts, went into Venetia and, with the help of the local custodians of works of art and monuments, began sending away the most precious paintings and objects of art from Treviso and Padua, Castelfranco, Congegliano, Vicenza and Verona; boxing up and packing away in safe cellars what could not then be shipped. But in Venice the palaces rest upon piles and they have no cellars. So, from the Galleria dell' Accademia, from the churches and monasteries, from the Doges' Palace, the Bellinis and Carpaccios, the Giorgiones and Titians, the Tintorettos and Veroneses, enclosed in enormous armored packing cases or rolled upon immense wooden cylinders, had to depart toward the south before the dark, threatening storm.

At the same time provision was made for the safeguarding of the most conspicuous monuments, and if it was not possible to protect everything—through the absolute impossibility of covering all the vast roofs of the naves, the cupolas and the campaniles of the thousand churches of Venice, Padua, Treviso, Vicenza, Verona, Bologna, Ravenna, Ancona, Bari and scores of other cities great and small, as well as the palaces that stand in them in crowds—all that was humanly possible to do was done. For example, among the things covered up were the facade of St. Mark's and the loggetta of the Campanile in Venice, the tombs of the Scaligers at Verona, Giotto's frescoes in the Arena and those of Mantagena in the Eremitani at Padua, the apse of San Vitale and the tomb of Galla Placidia at Ravenna, the Malatesta Chapels of St. Francis at Rimini, Giambologna's "Neptune" at Bologna, Corregio's cupola on the Duoma of Parma, the Arch of Torjan at Ancona and, above all, the superb doorways, mosaics, statues, frescoes, tombs and altars of the churches all along the Adriatic coast as far as Trani, and beyond.

So it is that, while, because of the impossibility of protecting the entire artistic wealth that exists in Italy, are to be recorded the ruins of the roof of the Scalzi, with the ceiling of Tiepolo, and the damage to Santa Maria Formosa, San Pietro di Castello, San Francesco della Vigna, Santi Giovanni e Paolo, and the Scuola Grande of St. Mark's (now the Civic Hospital), in Venice; those of Sant Apollinare Nuovo at Ravenna; those of St. Criaco and the door of the Lazzaretto at Ancona; those of the Duomo, the roof of the Baptistry and the cupola of the Carmini at Padua, and those of the Basilica of Aquileja, it is owing to such protection as it was possible to afford that the superb "Santa Barbara" of Palma Vecchio was far away from Santa Maria Formosa at the time of the ruin; that Vivarini's glass had been removed from the immense window of the Church of Santi Giovanni e Paolo and that its most beautiful sculptures had been covered up and its most precious paintings removed and carried elsewhere; that, finally, at the moment of the enemy invasion the most precious treasure of Gisulfo was no longer to be found in the Museum of Cividale in Friuli.

SAVING WORKS OF ART

As soon as the communications of the Supreme Command of the army made it possible in Rome to appreciate the full gravity of the collapse of the Italian front at Caporetto, and it seemed certain that part of the national territory would be invaded by the enemy, I was immediately summoned by the Minister of Public Instruction who entrusted to me the task of providing in every possible way for the protection and removal of all the monuments and works of art that remained in the zone of operations and in the provinces from which we should have to retire. I did not hide from myself the difficulties and the extreme delicacy of the task, but I accepted it with an enthusiasm that was in proportion to the gravity of the responsibility I was assuming. I had plenary and unreviewable powers, credits opened for me with the Banca d' Italia, assurance from the Supreme Command of the army that it would contribute men and means of transportation; I had the right to order by telegraph every employee of the Department of Fine Arts to go where I wanted him; and I started the same evening.

In the night, during the long sleepless hours of the journey, I rapidly laid out my plan of action. Up to that time, whatever had been done towards protecting the artistic patrimony of the nation had been directed almost entirely against dangers from incursions through the air, and from the bombardment of cities situated along our beautiful Adriatic coast. An absolutely different problem was presented now when through a wide breech in our battle-front were rushing not merely the masses of Germans and Austrians, burning with fierce and inextinguishable hatred, but also the barbarous hordes of Turks, Bulgars and Bosnians, and the Hungarian savages who inhabit the Alfold and the Tatra, all racing to sack the lovely rich plains of Friuli. It seemed to me in that terrible moment that I could only adhere to one very simple idea—get as close to the enemy as possible and begin clearing the towns, villas and churches of the country step by step as the Austro-German advance guard proceeded.

To put this plan into effect in the best way and in the briefest time, I divided the menaced teritory into several zones, each of which I confided at once to the intelligence and resourcefulness of the officials I had selected from the Department of Fine Arts, all of whom responded with admirable energy to my appeal and, careless of every risk and hardship, ready for the most fatiguing work, confronted without hesitation a gigantic task that was rendered infinitely more arduous by events and by the conditions under which the retreat of the army took

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In this article, translated by Arthur Benington, Dr. Colasanti describes how he and his assistants rescued the famous art treasures of Venetia, from the on-sweeping tide of Teutonic barbarians, often by almost incredible feats of engineering and oftener at the risk of their lives.

Taking down the famous horses of St. Mark's at Venice

place, and not only confronted it but completed it.

My first effort was to reach Latisana, on the Tagliamento, but I found it occupied by the enemy's troops. However, we reached San Vito in time and from there we rescued paintings and sacred furnishings; we reached Concordia and Caorle, where it was possible to recover the magnificent golden pall of the parish church; Vittoria Veneto, where we placed in safety a mediocre Titain and the amazing "Annunciation" which Vasari recorded as Andrea Previtali's masterpiece, and Quinto on the Sile, whence we took away Lorenzo Lotto's admirable panel. The cases containing all the treasures of the little museum of Oderzo, packed at random, left that smiling village at the very moment when the Austrian patrols were throwing their first footbridges across the river Livenza a few hundred yards away.

On November 3, when, utterly exhausted after 15 hours of continuous work, I was at Padua eating the only meal of the day, the representative of the Supreme Command notified me that the Fourth Army had begun the evacuation of Carnia and Cadore. I dashed for Belluno at once in an automobile and reached there after about seven hours of the most wearying traveling along roads congested by the wagons of the retreating army. Long lines of auto cars and tractors dragging immense cannon, endless columns of smaller artillery, alternated with magnificent regiments of Alpini, bersaglieri and infantry, grieving over the abandonment of the steep peaks of the Alps which they had won in two years of victorious battles, but preserving intact their faith in the destiny of their country. A spectacle of mute grief and conscious strength, of which I shall always preserve the remembrance.

I passed several hours of unspeakable anguish at Belluno, which I found already abandoned by the civil authorities and inhabited only by a few citizens trembling in anticipation of the imminent occupation by the enemy. All the collections of the Museum had already been packed in heavy cases, but means of transport were lacking. I turned back to obtain the necessary auto-trucks and, by working with incredible haste and with the willing cooperation of the Director of the Civic Museum of Padua, it was possible to carry away to safety, almost under the eyes of the Austrians, not only the entire contents of the Belluno Museum but all the most important works of art in upper Cadore, from the polyptych of Bellunello at Forni di Zoldo to the memorials of Pietro Clavi, a hero of our national Risorgimento.

In such a way dozens of towns, hundreds of churches villages and little museums between the Tagliamento and the Piave were cleared out; we packed and took away with primitive and often improvised means, under difficulties that in normal times would have seemed insurmountable, colossal works of art like the panel by Buonconsiglio in the Gallery at Montagnaga, Tiepolo's "Santa Tecla" belonging to Este Cathedral, which is 23 feet high; Veronese's "Santa Guistina" in the church of the same name at Padua, the area of which is 40 square metres; the enormous panel painted by Savoldo and Fra Pensaben for the Cathedral of Treviso, for which a special railroad car was necessary.

Long trains, made up of scores of cars, bore away to safe hiding places in the interior monuments taken apart, notable museums like those of Este, Treviso and Venice, gigantic marble groups and boxes of the most fragile Venetian glass. And, as the means of transit by land were insufficient, being almost wholly occupied with the necessities of the army, I dispatched by water several fleets of great barges laden with works of art, and the inhabitants of the villages scattered along the banks of the Po saw in amazement the horses of the superc quadriga that used to adorn the facade of the Basilica of St. Mark's pass up the river.

WHAT IS LEFT IN THE HANDS OF THE ENEMY

News of an exhibition of works of art from Upper Venetia and Friuli, held in Berlin and clamorously announced by the Germans, made me smile. For I know very well that, with the exception of a few splendid pictures found at Udine, which, through opposition suggested to the city's authorities by sentimental reasons and accepted by the Government with too much condescension, the Director General of Fine Arts was forbidden to remove in time, and outside of a few altar pieces in carved wood and a few sacred hangings left in Carnia from the same motives, our enemies could not have gathered up anything worth the trouble of exhibiting to satisfy the predatory instinct of the Berlinese public.

It is certain that in all the poorest churches of the Italian countryside, in every village, in every house are canvases and carvings and memoirs quite likely to seduce the coarse spirit of a German general; but, for the peace of mind of all who love the sublime treasure of beauty which constitutes my country's highest title of nobility, I can proclaim to the world that, if a reproof can be made to me and to my colleagues, it is that of having been excessive in precaution. For in many cases we obeyed, rather than true and just critical judgment, a sentimental impulse, an instinctive and unconquerable desire to abstract from the contamination of the bestial concupiscence of a savage enemy everything that in even a modest degree bore the esthetic label of our race.

To be absolutely precise, I will say that the works of art which I regret having had to leave in the invaded area are only three pictures. In the little town of Castel Roganziol is a triptych which an ancient document preserved in the parish church assigns to Titian, but which all the most highly reputed critics, from Cavalcaselle to Gronau, from Venturi to Berenson, attribute to some mediocre pupil of the great Venetian painter. Nevertheless, I had given orders to remove it, but when we arrived there we found the town deserted and the massive door of the church so securely closed that every effort to open it proved in vain. Another picture, a good panel of Pordenone, is still in a village fronting our lines. An inspector went to remove it, but it was so big and heavy that he could not get it upon the camion. The next day when we returned with a larger car to try to save it, that town was already occupied by the enemy. Finally, to another place close to the Piave, I sent the Superintendent of the Venetian Galleries to bring away a polyptych by a fifteenth century painter of the school of Giovanni Bellini, but for the same reasons that prevented the removal of the Pordenone, it could not be transported. The following day I sent a gigantic auto truck for it; the Austrians had not yet arrived, but both the polyptych and the contractor in whose custody it had been left had disappeared. Where? That is a mystery!

THE SOLDIERS OF NERVESA

I could have accomplished nothing, or very little, of my work without the constant, broadest, illuminated cooperation of the Supreme Command, the Secretary General for Civic Affairs, and every unit of the army. But above all I owe gratitude to the representative of the Command, Ugo Ojetti. This illustrious writer and able art critic devoted, and is still devoting, all his talent, all his activity, all his high competence, to the common work. Rapid organizer, wise counsellor, equally ready to direct and to execute, he gave me fraternal cooperation and shared with me the anxieties and the dangers, the responsibility and the satisfaction of success.

This happy and harmonious organization which produced its best fruits at the very moment of its improvisation, has been much admired and envied by our Allies. I myself, when at Asolo to take away Antonio Canova's magnificent marble "Paris," heard the French Alpine Chasseurs who were helping me in the difficult task, remark with regret that, if as much had been done in France, many treasures of art would have been saved from the blind vandal spirit and the rapacity of the boches.

It is incredible what jealous affection is displayed by soldiers for every mark, every relic, every vestige in which the Latin soul has revealed one of its dreams of immortal beauty. In emptying the Temple at Possagno in which the memorials of Canova are preserved, we naturally confined ourselves to placing in safety the original works of art, the great sculptor's sketches, and of the casts only those that are the sole record of works that have been destroyed or lost. But our good infantrymen could not get it into their heads why all those magnificent plaster reproductions of the "Perseus," the "Boxers," or the "Hercules and Lica" were left in place, and every now and then, whenever they find it possible, they send to me at Padua some of these cumbersome casts which they have recovered under the fire of the enemy, with infinite trouble and perpetual danger of death!

Removing the Madonna of the Church of L. S. Gionani and Paolo, at Venice

I could cite a thousand other examples of this worship of beauty, the more touching because blossoming in the rude, ingenious souls of peasants, but I will content myself with recording only one.

At Nervesa in the last days of November, an incendiary bomb almost entirely destroyed the ancient Villa Soderini, decorated by Tiepolo and his pupils. I knew that the single painting attributable with certainty to the great Venetian master—the ceiling of the central salon, representing the "Glory of the Flag of the Soderni"—had been knocked down and utterly ruined, but since I was informed that part of a decorative side-panel, depicting the "Entrance of the Gonfaloniere of the Soderini into Florence," remained still in place, I went to the spot on January 14th to see if it were possible to attempt to detach it from the wall. Nervesa lies on the bank of the Piave, and the Villa Soderini constitutes the most advanced salient of the little town, so that our first line trenches are dug right across the garden. To reach there is very dangerous, because, after passing across a broad zone that is murderously pounded by cannon, one has to proceed in the open, exposed to rifle fire. And yet, on this field of death, our soldiers in the moments they were away from the trenches for rest, had devoted themselves to hunting up and gathering together the fragments of the painted plaster, cleaning them lovingly, arranging them according to rooms, designs and colors. Every one of them had risked his life a hundred times under the illusion of being able to restore the lost masterpiece!

And when with a humble and spontaneous gesture they offered me these relics of a beauty that had perished forever, I could not keep back my tears.

[TO BE CONTINUED]

Skin Cancer

PERHAPS the most frequent excitant of all causes, so far as skin cancer is concerned, is dandruff. It falls from the scalp, and lights on the ear, eyelids, nose, neck, lips and face, and if there is already a scaling spot, or a thickening, or a wart, a mole, or a gland ready to receive the dandruff scale, it sets this spot alive with activity and it goes on to form a skin cancer. Probably 60 per cent of skin cancers are due to this cause, and many a cancer has been prevented and may be prevented by curing the dandruff or by preventing it.—*N. O. Med. and Surg. Journal.*

The Manufacture and Use of Die-Castings*

An Important Industry of Recent Development

By Charles Pack[1]

DIE-CASTINGS may be defined as metal castings made by forcing molten metal, under pressure, into a metallic mold known as the die. From this definition it follows, that for the successful operation of the die-casting process three factors must be considered as of vital importance:

1. A machine or appliance capable of holding the molten metal and delivering it under pressure into the die.
2. A suitable metal for use as a die material capable of withstanding the continued erosive action of the molten metal, as well as the rapid temperature changes to which it is of necessity subjected in service.
3. A metal or suitable alloy to meet existing conditions in the machine and mold.

The die-casting process is best adapted to small intricate parts where the cost of machining is an important factor. Where a sand casting can be used with little or no machining the die casting will be of no practical value, since the main function of the die-casting process is to reduce the machining cost of metal parts.

HISTORY AND EVOLUTION

Although the die-casting process as an individual industry dates back to a period not exceeding twenty years, metal molds were used as early as the fifteenth century. Whether the metal mold was first used for making printing type or pewter tableware is not definitely known, but that it was used by Gutenberg in 1454 for making his type is well known, since printing would never have been successful if it had been dependent for type upon the clay or loam molds and the crude machines of that period.

Pewter tableware was very fashionable during that period, and even during the colonial period in this country. That metal molds were used in casting pewter tableware is proved by various manuscripts and prints that are in existence. Ornaments, cheap statuary, etc., were cast in metal molds during the seventeenth century. Lead pipe was cast in iron molds as early as 1743.

Although the hand mold used during the eighteenth century for type casting was capable of producing about 5,000 individual types per day when in the hands of an experienced worker, it was soon found that it was entirely too slow to keep pace with the rapid progress being made in the printing art. Work was begun on the automatic type-casting machine early in the nineteenth century. Church's type caster was an English invention of 1822. It was claimed to be capable of producing 75,000 types an hour by casting a whole font at each operation. Following this invention came many others too numerous to mention here, and finally, in 1886, the first linotype machine with independent matrices was set up in the composing room of the *New York Tribune*. In this machine the metal is forced into a metallic mold formed by the assembly of the matrices. The type-metal is melted in an iron pot and is forced automatically by means of an immersed iron cylinder and piston into the mold, the sprue being cut and the casting ejected automatically. The principle was adopted in the construction of the die-casting machine and is used today in the most successful machines of this type.

The introduction of babbitt metals for anti-friction bearings created a demand for a die-casting machine, particularly since the advantages of a chilled babbitt were clearly understood. Many machines were constructed during the latter part of the nineteenth century and were used in some of the automobile plants for casting engine bearings. The first company was formed to manufacture and sell die-castings from zinc, tin and lead alloys at the beginning of the twentieth century in Syracuse, N. Y. The Doehler machine was patented in 1907. This machine was so successful that it was adopted by the largest companies in the country, including the Westinghouse Electric & Manufacturing Company, of this city, and the General Electric Company. The machine was also sold in England, Germany, Austria-Hungary, France and Canada, indicating that the die-casting process was distinctly an American development.

Another type of die-casting machine that is used to a limited extent by some manufacturers is known as the air machine. It consists primarily of an air-tight melting-pot with an air inlet and metal outlet. Compressed air or steam is forced onto the surface of the metal, forcing it through the outlet into the die. The design of the air machine may be varied to a large extent, but the basic principle as outlined generally remains the same. Many attempts have been made to remove the air from the die prior to casting, and so-called vacuum machines have been devised. I have had occasion to experiment with this type of machine and also to compare the product of this machine with the product of the plunger die-casting machine, and I am of the firm belief that no advantage is to be gained by the application of the vacuum principle to the die-casting machine either by itself or in combination with the air or plunger machine.

DIE CONSTRUCTION

The proper design of the die really constitutes the most important part of the successful die-casting process. The finest die-casting machine, combined with the most skillfully prepared alloys will not produce satisfactory die-castings if the proper attention has not been given to the gating, venting and general construction in the original design of the die. No given rule can be laid down for the design of all dies, and satisfactory results can be obtained only by employing men carefully trained through long periods of observation and experience. Only the highest type of skilled mechanic can be employed on the actual work of making these dies, since in many cases the parts to be produced from these dies must be held to a tolerance of $\pm$ .001 inch. The employment of second-rate mechanics on this class of work is a false economy and may often prove a costly mistake. The actual labor cost on a die may vary from $100, for simple parts, to $1,000 for more complicated parts, requiring from two weeks' to four months' time on the part of one or more skilled mechanics. With these facts in view, it can readly be understood how costly an error may prove, particularly when made in the final stage of the die construction.

APPLICATION IN ENGINEERING PRACTICE

It is evident from the foregoing that the use of die-cast parts cannot be considered an economical proposition where only small quantities of castings are required, since the initial die charge when pro-rated over the castings required may then wipe out any possible saving over the other methods of production. The minimum practical quantity depends largely upon the number and complexity of the machine operations that can be saved on the particular part in question. I have seen very few machine parts that could not be produced more cheaply by other methods of production where the quantity required was less than 1,000. When quantities of 10,000 or more similar parts are required the die charge is readily absorbed and fades into insignificance.

The die-casting alloy should be given careful consideration by the engineer before deciding upon the use of a die-cast part. The days have long since passed when a manufacturer could sell die-castings made from some mysterious, secret alloy unknown to the art. However, it must also be borne in mind that the analysis of the alloy is not always a true indication of the quality of the die-cast part, since the method of alloying and the care of the alloy during the process are of more importance in this industry than in foundry practice.

As stated before, the first die-castings were made from zinc, tin and lead alloys due to their comparatively low fusing points. The physical properties of these alloys when compared with the alloys of aluminum, copper, and iron were so poor that die-casting manufacturers soon recognized the importance of developing a process of die-casting the higher fusing-point alloys. Experiments were made with brass die-casting machines as early as 1907, but it was not until 1914 that the Doehler aluminum die-casting process was developed sufficiently to take its place among the commercial methods of production. At various intervals before and since that time enthusiastic theorists have arisen with the shot, "We have it," only to find that some small but important factor was overlooked. Advertisements in trade periodicals for the past ten years show that at regular intervals brass die-casting companies have sprung up like mushrooms and disappeared just as fast. I have here some samples of brass die-castings made in 1907, but nevertheless, it is only during the past year that we have been able to produce finished brass castings on a limited, commercial, competitive basis, and then only by a radical departure from the methods used in 1907.

PROPERTIES OF ZINC-ALLOY DIE-CASTINGS

Prior to 1914, 90 per cent of all die castings produced were made from zinc-base alloys, of which the following is a typical analysis:

Zinc	84.5 per cent
Tin	9.0 per cent
Copper	4.5 per cent
Aluminum	2.0 per cent

The tin, copper, and aluminum contents of the alloys were varied to suit the particular manipulator.

Extravagant claims have been made for these zinc alloys, and even today they are advertised by some irresponsible manufacturers to have the strength of soft brass. Zinc alloys can be made to test 18,000 to 20,000 pounds tensile strength, but due to the treacherous crystalline nature of these alloys, I would not consider their use in vital machine parts where even one-half of this strength is actually required. To say that zinc-alloy die-castings are as strong as soft brass is absolutely false and misleading. Where a hard alloy is required for a part not subject to severe or sudden strains the zinc alloy will answer the purpose. Zinc-alloy die-castings are being used with satisfactory results for magneto housings, switch locks, switch handles, self-starting devices, oil-pump parts, speed indicators, wind-shield nuts, drinking-cup machines, gum and candy-vending machines, cigar and stamp-vending machines, check protectors, stamp-affixing machines, phonograph elbows and sound boxes, besides numerous other devices too numerous to mention. The poor physical properties of the zinc alloy may, to a large extent, be counteracted by redesigning the machine parts to meet the conditions. Ribs, webs and fillets may be added and iron, steel, or brass parts inserted where strength is required. Zinc-alloy die-castings may be plated with nickel, brass, silver or gold. Zinc alloys of the type given are corroded by water and aqueous solutions of any kind. Acids and alkalis attack these alloys readily and their use in food containers should be prohibited. Zinc-alloy die-castings may be buffed to a high luster, but tarnish rapidly upon exposure.

The highest possible melting-point of the zinc-group alloys is 750 degrees F. Alloys of the type given will begin to fuse at 350 degrees F., and will be liquid at 780 degrees. It is not advisable, therefore, to use zinc alloys where abnormal temperature conditions are likely to exist.

PROPERTIES OF TIN-ALLOY DIE-CASTINGS

Tin-alloy die-castings may be used for food-container parts, hygienic and surgical instruments, milking machines and dairy utensils, and for other machine parts where non-corrosive properties are desired and strength is of minor importance. These alloys are comparatively soft and have a maximum fusing-point of 425 degrees F. The most important use of tin-alloy die-castings is in the production of babbitt bearings for internal-combustion engines.

Babbitt metal as originally patented by Isaac Babbitt consisted of tin, copper and antimony, with the first-named element in preponderance. Babbitt's formula has been varied to a large extent to suit different engineers. Some so-called babbits on the market today contain no antimony; some contain varying proportions of zinc; many contain lead; while others contain little or no tin. Genuine babbitt metal, however, as understood by engineers consists of tin alloyed with copper and antimony. Zinc and lead are regarded as objectionable impurities.

The hardness of babbitt metal may be varied within certain limits. Generally the harder metal will also have a greater compressive strength, which is greatly to be desired in motor bearings. Unfortunately, any increase in hardness is usually accompanied by a reduction in elongation or increase in brittleness. To overcome these drawbacks the babbitt-lined, bronze-back bearing has been devised and is now used exclusively in the manufacture of the highest grades of internal-combustion engines for use in automobiles, motor boats and aeroplanes. The bronze-back bearing is used for connecting-rod and main-shaft bearings on all aeroplane motors made in this country.

PROPERTIES OF LEAD-ALLOY DIE-CASTINGS

These alloys consist of lead alloyed with varying proportions of antimony and tin. These alloys are so well known to the art that very little need be said here beyond the statement that an alloy made from any practical combination of these three elements is suitable for die-casting. The maximum melting-point of any lead-base alloy is 620 degrees F.

Lead-alloy die-castings are used where a cheap non-corrosive alloy is required and where strength is of minor importance. Lead-alloy die-castings are used exten-

*A paper read before the Engineers Society of Western Pennsylvania, and published in the Proceedings of the Society.

[1]Chief Chemist and Metallurgist, Doehler Die-Casting Company.

sively in fire-extinguishers, fuse-hole plugs on shrapnel shells, fuse-timing devices, hand grenades, rifle grenades, shell parts, etc.

PROPERTIES OF ALUMINUM-ALLOY DIE-CASTINGS

The alloys used in the Doehler aluminum process are of the aluminum-copper type and contain no zinc, tin, lead or other low-fusing elements. The process and alloys are covered by patents, which are now being litigated in the courts.

The melting-point of these alloys is approximately 1,200 degrees F. and the tensile strength 25,000 pounds per square inch. Alloys of this type have been used in automobile construction for the past twenty-five years, and need no introduction here. The hardness may be varied by either increasing or decreasing the copper content. The alloy takes a high polish under the buff and retains it well under atmospheric conditions. It resists the action of weak organic acids and weak nitric acid, but is rapidly corroded by salt water, hydrochloric acid, sulphuric acid and alkalis.

Aluminum die-castings are superior to zinc die-castings for the following reasons:

1. Freedom from the crystal line structure that characterizes the zinc castings. The aluminum die-castings are therefore more permanent and reliable.
2. Greater strength of the aluminum alloy.
3. Lower specific gravity.
4. Higher melting-point and greater resistance to varying temperature conditions.
5. Greater elongation.

During the past two years the Doehler aluminum process has been developed to such a high degree of efficiency that it is possible to die-cast in aluminum any part that is now being die-cast in zinc. The abnormal cost of aluminum at the present time, coupled with the fact that the zinc die-casting process is older and better understood, makes the aluminum die-casting somewhat more expensive than the zinc die-casting. The higher cost of the aluminum die-casting prevents its entirely displacing the zinc die-casting where the latter is being used today.

BRASS AND BRONZE DIE-CASTINGS

The die-casting of brass and bronze has been for many years the fond ambition of all die-casting manufacturers. Processes have been devised which produced very promising samples, but they were invariably failures when tried on a commercial basis.

During the past year we have been able to develop the die-casting of brass on a commercial basis. Past experience has taught us to proceed slowly and cautiously, but we are today producing at the rate of approximately 1,000 pounds of brass per day, and feel justified in saying that the brass die-casting is now an established commercial product. Brass die-castings are now being produced for use in submersible bombs, naval torpedoes, starting and lighting systems, cream separators, turbine engines, wind-shield fixtures, railroad steam couplings, carbureter parts, retainers for ball and roller bearings, gas-meter parts, water-meter parts, etc.

We have for the present limited ourselves to the use of the copper-zinc type of brasses, which include the so-called manganese bronzes. The process is not limited to this group of alloys, but it was thought advisable to concentrate on one type of alloy for the present. The copper-zinc alloys have been thoroughly described in metallurgical treatises, and I do not believe it necessary to give their properties in detail in this paper.

CONCLUSION

Although the die-casting industry has made rapid strides during the past five years, and has become recognized as one of the most important branches of the non-ferrous metal industry, it is safe to predict that it is still in its infancy. The improvements that may be expected in the aluminum die-casting process in the future make it reasonably certain that the aluminum sand-casting process will be used only for exceedingly large parts. Experiments have been made with iron die-castings, but the die-casting of aluminum, brass and bronze presents enough problems to keep the chemical and mechanical engineers engaged in this industry busy for some time to come.

DISCUSSION

MR. JESSE L. JONES:[3] I think Mr. Pack is slightly in error in regard to his statement that zinc-base die-casting metal may not be as strong as soft brass. The alloy known as lumen-bronze, which consists of 85 per cent zinc, 10 per cent copper and 5 per cent aluminum, may have a tensile strength as high as 40,000 or 50,000 which is much in excess of the strength of cast brass. However, it has practically no ductility, and for uses where ductility is important it is of no value.

[3]Engineer, Research Division, Engineering Department, Westinghouse Electric & Manufacturing Company, East Pittsburgh, Pa.

Mr. Pack referred also to lead-base die-castings. A type of lead-base die-casting alloy that has been brought out by Dr. F. C. Frary, of the University of Minnesota, is of considerable interest. This alloy is hardened with calcium and barium and has one very peculiar characteristic. It is harder after a week or so than it is when cast. A hardness of 27 or 28 points Brinell is claimed for the alloy, but what I have tested reached only 23 or 24. The hardness was 18 when cast. I have seen no explanation of this change. It is supposed to be a desirable characteristic, as you can line a bearing, have it seated on a shaft while it is soft and then obtain the increased hardness, which is due to the change that occurs in the alloy and which presumably would make the bearing more durable. One difficulty with this alloy is that the calcium or barium oxidizes very rapidly at a temperature of 700 degrees F. and above. When this oxidation occurs the molten metal has a peculiar surface appearance resembling that of mercury. Owing to this oxidation defect, it is impossible to cast this alloy in the ordinary manner and it has to be die-cast. I understand one of the motor companies is using this alloy in large quantities.

MR. PACK: Mr. Jones made the point that zinc alloys, or some of them, have the strength of brass—a tensile strength of 25,000 or 30,000 pounds per square inch. The fact that you can make an alloy and put it into a test bar and pull it 25,000 or 30,000 pounds does not give the same die-casting manufacturer license to advertise the strength of his alloys as such. There are a number of reasons. For instance, take this part (showing). Assuming that it had been made from a certain alloy, who can say at any time just what particular strains are set up in the actual casting operation? You have a permanent core here and the material cannot compress the core as it does with sand casting. Just what the effect of the core is on that casting no one can tell. The man who advertises the strength of such an alloy as 35,000 pounds knows that it is not nearly that, and he should not so advertise it.

There is another point that I omitted. The general impression of the man who is not familiar with die-castings is that, when you take a pot of molten metal and force it into the die, the metal will be denser and have a closer fracture than a metal which is poured by gravity. That is a mistake. As a general rule, die-castings have a porous structure and are not as solid as sand castings. The difference is that when castings are put into a mold made of sand the metal has a chance to flow together and the air will leave the mold through the ports of the mold itself. In the die-casting process the metal goes into the mold in a fraction of a second and it is almost impossible to devise a die, and so vent and gate it that the air in all these pockets will travel out in the proper way. At any rate, it has never been done.

I have here an article on die-castings in which the author claims to have eliminated blow-holes by creating a vacuum inside the die. His theory is that if you take the air out of a die you will have no air left to put in the casting. But he does not tell us that as far as the actual value of the casting is concerned a vacuum is no more desirable than an air-hole inside the casting. You have no metal there in either case. The presence of blow-holes in die-castings is not due so much to the fact that there is air present in the die as the fact that the metal will splash and chill on the outer surface of the die, preventing the metal from feeding to the center afterward. Whether you have air inside or vacuum inside does not make much difference. The vacuum process has been tried and discarded. We must admit that blow-holes are a factor to be considered in die-castings, but bear in mind that it is possible by special attention to a certain part to get your gates and vents so perfected that a solid casting can be produced. This has been done with motor bearings, where it is important that you get solid bearings. That is why solidity is claimed for certain castings and not claimed for others. So aside from the factor of possible casting strains the question of blow-holes comes in, and no man can predict just where those blow-holes will be. It is for that reason that I make the point in my paper that it is misleading to assume that zinc die-castings are anywhere near as strong as brass.

Blast-Furnace "Bears"

DR. J. E. STEAD gave before the Iron and Steel Institute a study of the great variety of substances found in blast-furnace "bears."

A bear, sometimes called an old horse, a sow, or a salamander, is the mass of metal found below the hearth-level of a blast furnace after the furnace has been blown out. During the working life of furnaces the base or bottom linings are more or less fluxed away and replaced by metal which, being below the tapping-hole, cannot be run out. In the course of time the metal gradually works its way downward for a distance of 3 feet to 12 feet or more, and as it cannot be removed in the liquid state, it solidifies into masses which may weigh anything between 50 and 800 tons.

These immense blocks of metal are usually broken up bit by bit by drilling and blasting, and the interior structure can then be readily seen. In all cases the feature which first strikes the observer is the presence of considerable quantities of what appears to be kish or graphite, also grey metal of very open fracture, which has broken along the cleavages of large plates of graphite, and metal of all degrees of greyness progressively from the very open to the very close and on to the mottled and white. Conglomerates of kish, metal and partly-fused brickwork, through which pass veins of a metallic substance, are often found. Sometimes specimens are met with which have the same color as copper and are rich in what has been described as nitrocyanide of titanium, but since the adoption of higher furnaces and greater blast pressures large accumulations of this substance are rare, though it is always present as disseminated crystals. In some bears the nitrocyanide is associated with dark blue idiomorphic crystals (titanium dicyanide), quite insoluble even in strong hydrochloric acid, and the feature of the conglomerate has a blue cast. In the drusy cavity of one bear from the hearth of a furnace that has been making ferro-manganese Mr. Poulaine discovered large idiomorphic crystals of double carbide and silicide of manganese and iron.

In more than one bear a considerable quantity of carbonless iron rich in phosphorus has been found, and in another a substance closely resembling mill cinder was observed. In many bears the lower central axes have a columnar structure almost identical with the basaltic formation of Staffa and the Giant's Causeway, though the columns are relatively much shorter and of smaller diameter, the actual lengths varying from a few inches to more than a foot and the diameters from 1/8-inch to 1/2-inch. One authority claims that he has found diamonds in a German bear, but, so far as is known, they have not been discovered in an English bear. Crystals analogous to rhabdite have been found, and conglomerates containing up to 66 per cent of almost pure manganese sulphide and mixed sulphides of manganese and iron.—Engineering Supplement of the *London Times.*

The Infectivity of Trench Fever

TRENCH fever has been reported only from the war zones and is known to be a louse-borne disease, perhaps carried by the excreta rather than by the bite of the parasite, although the actual virus remains undiscovered. The extent of our present knowledge of the disease is ably summarized in a paper by Major W. Byam, R.A.M.C., and his co-workers at the Hampstead Military Hospital, opening a discussion at the Society of Tropical Medicine on May 17th. Meantime a group of American soldiers in France have made it possible to advance our knowledge very materially on the subject of the infection of trench fever and its mode of conveyance. At its inaugural meeting last October the Medical Research Committee of the American Red Cross appointed a Commission with a view of confirming and extending the work of Major J. W. McNee, R.A.M.C. In the research, which was carried out at a stationary hospital of the B.E.F., six medical officers of the American Reserve Corps (Majors R. P. Strong, H. F. Swift, and E. L. Opie, and Captains W. J. MacNeal, W. Baetjer, and A. M. Pappenheimer), were associated with Lieutenant A. D. Peacock, R.A.M.C. Sixty-eight volunteers from the U. S. Army, all of them in robust health, were examined by physical, bacteriological, and serological tests before the investigation began, and means were taken to prevent them from becoming lousy by accident. In the first series of experiments 34 men were inoculated with blood or some constituent element of it from trench fever cases in a febrile stage, and of these 23 developed typical trench fever—viz., 15 out of 16 who were inoculated with whole blood, 5 out of 5 with clear unfiltered plasma, 3 out of 4 with washed corpuscles, none out of 7 with plasma, serum, or ground corpuscles filtered through Berkefeld candles. The incubation period after blood inoculation varied from 5 to 20 days, being longer with blood taken late in the disease. The first and second days of the attack were shown to be the most infectious. Inoculation was carried as far as the fourth generation of the disease. The second series of experiments deal with the transmission of infection by the louse. Of 26 men subjected to the attentions of *P. corporis* previously fed on trench fever cases 12 contracted trench fever, the incubation period varying from 16 to 35 days. Apart from taking longer to develop, the disease produced by the louse appeared identical with that produced by direct inoculation of blood. The work is held by its authors to demonstrate that trench fever is a specific entity and not a form of enteric fever, and has definitely added to our knowledge of the etiology of the disease. Other aspects of the infection are left over for discussion in a later report.—*The Lancet.*

The Relationship of the Most Ancient Flint Implements

To the Later River-Drift Palæoliths*

By J. Reid Moir, F.R.A.I.

There are very few serious prehistorians of the present day who believe that the earliest palæolithic implements of the river-drift represent man's first efforts to fashion flints to his needs.

If a typical example of these implements be examined, it will be recognized at once that the specimen owes its outline and form to a series of dexterous blows delivered by some one with a very definite idea of the kind of implement he wished to produce, and a thorough grasp of the art of flint flaking. It would seem to be contrary to reason and experience to suppose that some primitive being in the remote past should, without any prior knowledge of the flaking of flint, be able to produce such a specimen. And this opinion is strengthened if we try to conjecture what a present-day member of the human race would be able to accomplish in implement-making under similar circumstances.

Let us suppose that a person who had no knowledge of the fracture of flint, and had never seen or heard of such things as flint implements, was confronted with a block of flint and a hammer-stone. It may be supposed, also, that the present-day representative of mankind would possess a brain more alert and receptive than his ancient and untutored ancestor. And yet even with this very great advantage is it possible to believe that the modern person would be able to produce a symmetrical and well-flaked palæolith? The answer to this question must, in the author's opinion, be a decided negative, and he considers that there is no reason to believe that any ancient and primitive member of the human race would, under the same circumstances of ignorance, be any more successful.

It seems then that the earliest palæolithic implements cannot represent man's first efforts in flint-flaking, but are, in all probability, the outcome of long periods of time, during which a slow process of evolution in flint-implement making was in progress. And this seems a reasonable supposition. The flaking of flint is an art, one which might perhaps be termed an "industrial art," and we are all aware that most, if not all, art has slowly evolved, and is still evolving. It is no doubt somewhat difficult for us, who are familiar with all and every form of elaborately flaked flint implements, to realize that the person who made the first and most primitive edge-trimmed scraper or borer was, no doubt, regarded by the other members of the horde as an expert flaker of flint. He was as a matter of fact much more than that, he was a discoverer, a maker of new knowledge, which was to be of enormous value to his contemporaries and to those who lived after him. And so it was with all advances in implement making: they must have been epoch marking in the same way as great advances in various ways are at the present day. There seems little doubt from the scanty signs of improvement in the flint implements of

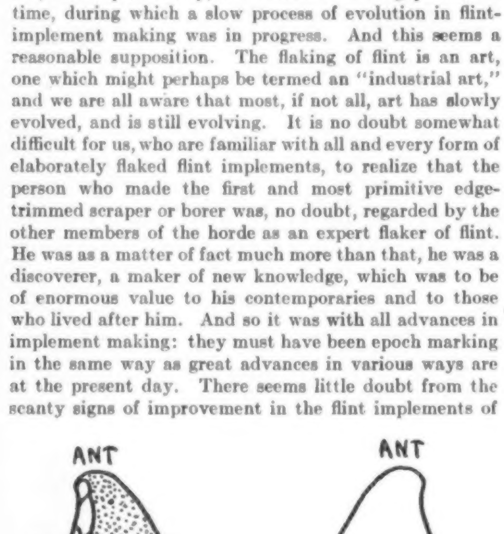


Fig. 1

any given geological horizon, that evolution in implement making proceeded very slowly. But this need not necessarily cause surprise when the lack of incentive to progress, and the general low standard of mental power of the primitive human beings are considered.

*From *Science Progress*.

In the present paper the author desires to draw attention to the apparent relationship of the most ancient and primitive edge-trimmed implements (generally known as "eoliths"), to the later and more highly evolved palæoliths such as are found usually in river-terrace gravels, etc. The author would like it to be understood that this supposed relationship extends only to the St. Acheul river-drift implements, and that he makes no claim, at present, to associate the later palæolithic specimens of the Moustier, Aurignac, Solutré, and Madeleine periods with the above-mentioned edge-trimmed eolithic flints.

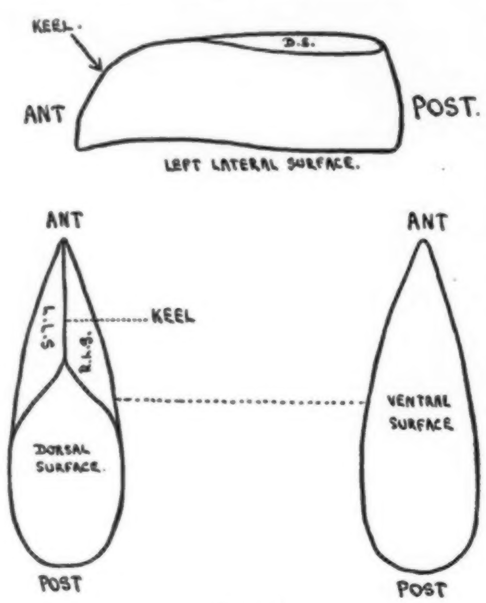


Fig. A

It has generally been held that the beds containing the pre-palæolithic implements were separated by a considerable period of time from those in which the normal palæoliths occur; and this may or may not be true. But the author is concerned solely with the form and flaking of the various specimens described in this paper, and the somewhat complex geological problems involved in their provenance must be left to others for solution. After careful thought it has been decided, for the sake of clearness, to illustrate this paper by means of slightly "idealized" drawings. These drawings, however, have been executed under the close supervision of the author, and are based upon a large series of actual implements. But before proceeding to describe these drawings it is necessary to write a few lines on the question of flint-flaking. To every one who has taken the trouble, or rather experienced the pleasure of flaking flint, it has become clear that to be able to detach flakes with precision, it is needful, whenever possible, to have a flat surface upon which to deliver the necessary blows. It is almost impossible to detach flakes from a rounded surface of flint owing to the fact that the hammer-stone cannot "get home," so to speak, but glances off ineffectively. There is no doubt that the necessity for a flat surface of flint in flaking was one of the first discoveries made by man in his earliest efforts to shape flints to his needs. The most ancient edge-trimmed stones are almost invariably of a tabular form, and it seems that these stones were selected because they afforded two naturally formed broad flat surfaces upon which to deliver blows with a hammer-stone. As time went on, as will be shown, it was found possible to produce the necessary flat surface by flaking, and this production of a "striking-platform" was, and always must be, one of the fundamental necessities in flint-implement making. In the author's opinion the rostrocarinate or "eagle's beak" type of implement plays an important part in the evolution which it is the intention of this paper to describe.[1] It seems necessary, therefore, to give an accurate description and drawing of an ideal rostro-carinate implement, such as the ancient flakers of flint apparently had in their mind, but to which ideal they did not often attain.

[1]See *Journal of the Royal Anthropological Institute*, Vol. XLVI, January-June 1916. These particular specimens were first found by the author in 1909 in the detritus-bed below the Pliocene Red Crag of Suffolk, and have been described fully by Sir Ray Lankester and by himself.

The following description is copied from that given in Sir Ray Lankester's Memoir (*Phil. Trans. Roy. Soc.*, May 1912) and the accompanying drawing of an ideal rostro-carinate is also taken from the same publication.

A rostro-carinate is an implement with broad posterior region, narrowed anteriorly to a quasi-vertical cutting edge. This anterior narrow edge is strongly curved and gives the implement the form of the beak of an accipitrine bird. The form of this region of the implement may also be compared to that of the prow of a boat (the boat being turned keel upwards). If the implement is held with the prow or beak to the front, there are observed an upper or dorsal plane, a lower or ventral plane, a right lateral and left lateral surface, a posterior surface or stern, and an anterior surface, narrowed to the form of a keel and ending in a beak (hence the term "rostro-carinate") as a consequence of the oblique direction and convergence of the lateral surfaces, which approach one another so as to leave only a narrow keel-like ridge between them (see Fig. A). It is proposed to indicate in each text figure the anterior (Ant) and posterior (Post) region of each specimen portrayed. The upper, dorsal surface, and the lower, ventral surface, will be indicated by the letters D.S. and V.S. respectively, while the left lateral surface (L.L.S.) and the right lateral surface (R.L.S.) will also be delineated. A sectional drawing of each implement will also be given.

The "keel" of the specimens exhibiting this feature will be indicated clearly, and the author thinks that the drawings will be readily understood by the reader. The arrows marked in on the flake-areas of the specimens indicate the direction of the blows which removed the flakes.

Fig. 1. The most primitive type of flint implement known is here represented. It is simply a more or less tabular piece of flint, the dorsal surface of which exhibits unflaked cortex, while the ventral surface shows the hard interior of the flint which has become exposed owing to a clean thermal fracture. On one side of this flat thermal fracture surface blows have been delivered and flakes removed, so that a hollow has been produced in the edge of the stone, which encroaches on the dorsal surface. It will be noticed that all the arrows marked in on the flake areas of this hollow, which forms part of the left lateral surface of the implement, point away from the flat ventral surface, demonstrating that the maker of the implement delivered all his blows upon this flat surface. And any one experienced in the flaking of flint would follow his example, as the more uneven dorsal surface would afford a much less satisfactory striking-platform upon which to deliver flake-removing blows with precision. The specimen is D-shaped in section. Such an implement would be of service for scraping purposes, and the type is frequently met with in the high plateau gravels

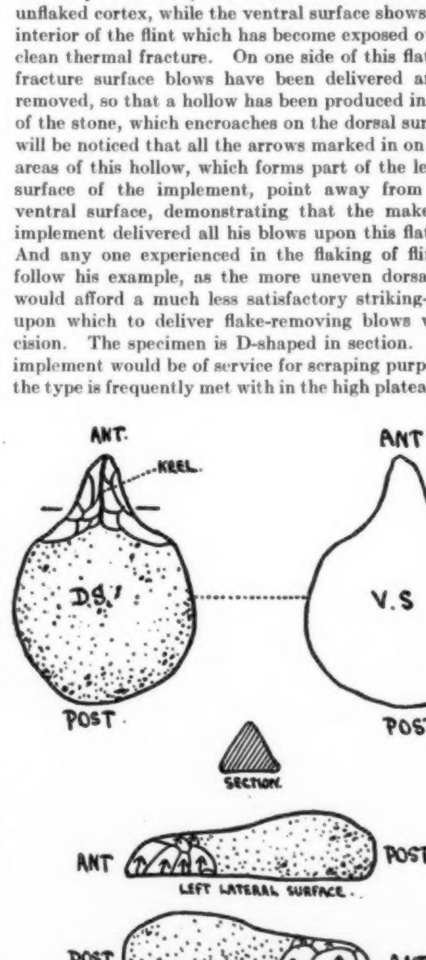


Fig. 2

of Kent, and in other ancient deposits of pre-palæolithic age.

Fig. 2. Represents another very primitive type of flint implement often found in association with the form

represented in Fig. 1. This specimen (Fig. 2), however, exhibits an advance on the first described implement. It will be seen that another hollow has been flaked in the side of the stone opposite to that shown in Fig. 1, and that the specimen has now assumed a definite pointed form. The production of this extra hollow would have provided the ancient flint flaker with two scraping edges instead of one, and it is the author's opinion that this was the result which he wished to attain. The pointed form was simply the inevitable result of the production of the two opposing hollows. But there was also another inevitable result which, apparently, had a great effect in the evolution of flint implements. As the respective fracture-surfaces of the two hollows encroached upon the

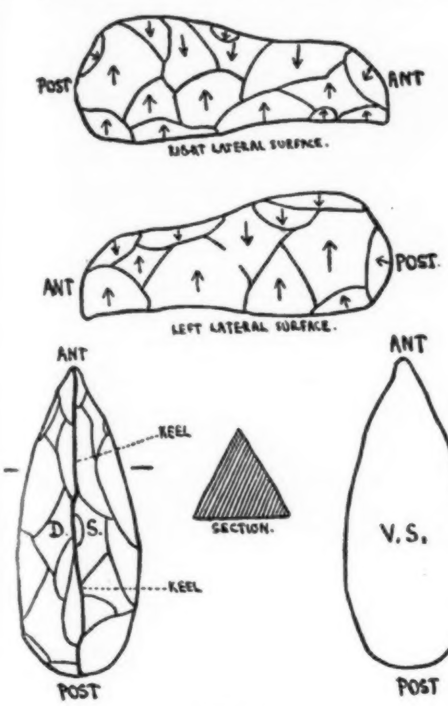


Fig. 4

dorsal surface of the specimen, and finally met, a ridge or gable was formed (marked keel in drawing). It does not appear probable that the formation of this keel was the object of the ancient workman, but that it was the inevitable outcome of the production of the two hollows, as any one can easily prove by flaking a flint to the form of the specimen represented in Fig. 2. But it was not long before the possibilities of this sharp keel being used as a cutting-edge, and its superiority as such over the cutting-edges in use previously, were recognized, and from then onwards the efforts of these early flint flakers appear to have been directed to the production of such "keels" or cutting edges.

The right lateral and left lateral views of the specimen show that, as in the implement represented in Fig. 1, all the blows forming the two hollows were delivered on the flat ventral surface. A glance at either of these lateral views will show also that the anterior region has already assumed in profile the appearance of a beak, and is prophetic of the later rostro-carinate specimens. This beak-like appearance is again attributable to the production of the two opposing hollows, and is the almost inevitable result of such production, as can easily be tested by any one desirous of doing so.

The section of the specimen is triangular, the base of the triangle representing the ventral surface, the two sides the right lateral and left lateral surfaces respectively, while the apex represents the keel or gable formed by the convergence of the flake areas, forming the two opposing hollows. It will be noticed that both the implements represented in Figs. 1 and 2 are fashioned from pieces of tabular flint which provided naturally formed striking-platforms for the delivery of flake-removing blows.

Fig. 3. Represents a rostro-carinate or eagle's beak implement such as is found in the detritus-bed below the Pliocene Red Crag of Suffolk. It appears that at the time when these implements were fashioned tabular flint was not obtainable, as the author has not yet found a sub-crag rostro-carinate made from a piece of tabular flint, and the extensive diggings which have been conducted have shown that this particular kind of flint is hardly ever found in the detritus-bed.

The pre-Crag people, however, had an abundance of flint of very fine quality, in the form of nodules, with which to work, but the more or less rounded surfaces of nodules did not afford a satisfactory striking-platform, and so they had to learn to provide themselves by flaking with a flat surface upon which blows could be struck with precision. There is no doubt that the sub-Crag rostro-carinate implement, though generally much larger and of a more imposing appearance than the primitive implement represented in Fig. 2, is nevertheless made on almost the same lines. The ventral surface of the rostro-carinate formed by the removal of a large flake from the

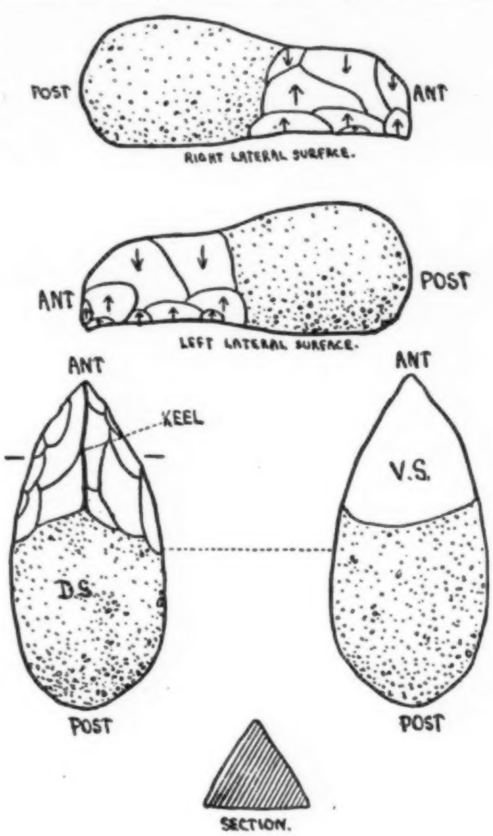
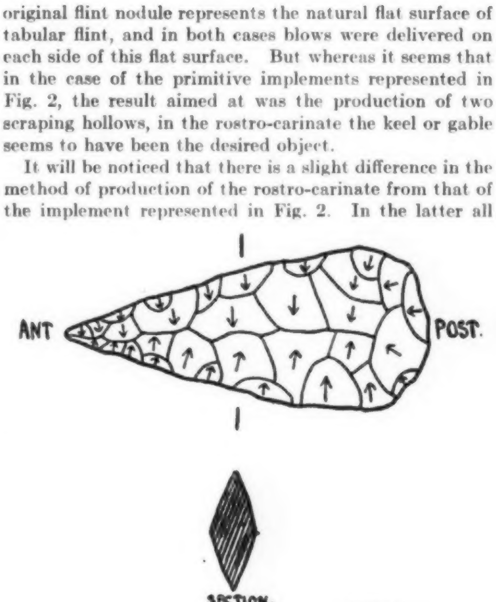


Fig. 3

original flint nodule represents the natural flat surface of tabular flint, and in both cases blows were delivered on each side of this flat surface. But whereas it seems that in the case of the primitive implements represented in Fig. 2, the result aimed at was the production of two scraping hollows, in the rostro-carinate the keel or gable seems to have been the desired object.

It will be noticed that there is a slight difference in the method of production of the rostro-carinate from that of the implement represented in Fig. 2. In the latter all



Figs. 6 and 7

the blows were delivered on the flat ventral surface, and while this is the case with most of the blows which went to form the keel of the rostro-carinate, yet one or two were delivered on the dorsal surface of the specimen. The author has found by many experiments in flint-making that in forming the keel it is sometimes necessary to deliver some blows on the dorsal surface. The section of the rostro-carinate implement is triangular as in the case of Fig. 2.

Fig. 4. It has been noticed, from an examination of a number of rostro-carinate specimens found in deposits of less antiquity than the detritus-bed below the Pliocene Red Crag, but more ancient than the river valley gravels, etc., that the ventral surface or "striking-platform" as it might be termed, was gradually extended further backward toward the posterior region of the implement.

This extension of the ventral surface made possible the corresponding extension of the keel, until an implement was produced having a cutting edge extending the whole length of its dorsal surface. Such a specimen is illustrated in Fig. 4. The section of this implement is still triangular, and the majority of the blows forming the keel were delivered upon the flat ventral surface. Several specimens of this type have been found from time to time in river-gravels associated with early palæolithic

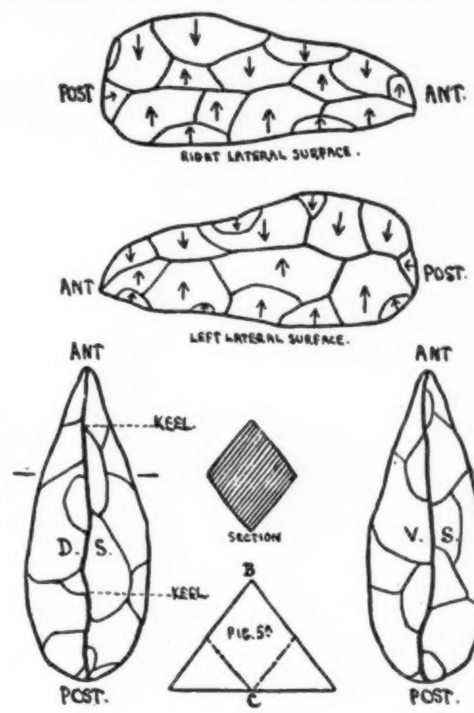


Fig. 5

implements, and long before rostro-carinates were discovered were collected and preserved as "side-choppers." But there can be little doubt that such specimens are simply rostro-carinate implements in a high state of development, and moreover their method of manufacture is fundamentally the same as that followed in the production of the more primitive implements illustrated in Figs. 2 and 3. This fact can be easily corroborated by any one prepared to experiment in flint flaking on his own account.

Fig. 5. It seems that the palæolithic workmen having realized the advantage of a cutting-edge extending the whole length of the dorsal surface of their implements, realized also that it would be a great advantage to have at their disposal another and opposite cutting-edge. We have seen that so far in implement-making the flat ventral surface had been an absolute necessity for the production of the required cutting edges. On this ventral surface or striking-platform the majority of the blows had been delivered, and it was the presence of this same flat surface which made it possible for the palæolithic workman to develop his implements still further. If a number of the earliest palæoliths are examined it will be noticed that they are roughly rhomboidal in section and thus differ from the triangular form of the implements represented in Figs. 2 and 3. Fig. 5a shows how, in all probability, this change from the triangular to the rhomboidal form was brought about. The two areas indicated by crosses and limited by dotted lines were removed by blows delivered principally upon the flat ventral surface, or base of the triangle, and a cutting edge (*C*) formed in opposition to that at *B*, which, as we have seen, was the keel of the more primitive type of implements.

The author has been able to examine a large number of early palæolithic implements in various public and private collections and has recognized many specimens which, though exhibiting the two cutting-edges of the normal palæolith, nevertheless show in their profile a marked resemblance to the profile of the rostro-carinate implements (Fig. 5). That is to say that one edge of these early palæoliths is markedly curved towards the anterior region of the implement, while the other edge is much straighter.[2] He has noticed also that many of these specimens exhibit the remains of either the dorsal or ventral surfaces of the rostro-carinate form. Such a

[2]The downward curvature of one edge represents the curving of the keel toward the anterior region, while the straighter edge represents the flat ventral surface of the rostro-carinate form.

resemblance would be expected if the palæoliths were evolved from the rostro-carinates, and it is very significant that such forms should occur so freely in the earliest palæoliths which are nearest in point of time to the rostro-carinates.

The author has experimented extensively in the flaking of flint, and has himself produced flint implements of early palæolithic type by following the procedure outlined above and he has found that in several cases the outline of the rostro-carinate form has been preserved. He has found also that the remains of either the dorsal or ventral surfaces of the rostro-carinate are sometimes left at the butt-end or posterior region of the implement. It has been the custom to figure and regard palæolithic implements with their points uppermost, and in consequence the remains of the dorsal or ventral surfaces have been spoken of as "lateral platforms." But if these specimens are regarded with the point to the left or the right as the case may be, these platforms are no longer lateral, but dorsal or ventral, and their true significance can be recognized.

Fig. 6. This drawing represents a highly evolved palæolithic implement in which both edges are symmetrical, and the likeness to the ancestral rostro-carinate form has almost disappeared.

Fig. 7. Represents an ovate palæolithic implement. These implements, which were made on precisely the same plan as the pointed examples, owe their ovoid shape to the substitution of a rounded cutting edge for the pointed end, and their evolution may be due to the breaking off of the area indicated by crosses, and the re-chipping of the broken end into a curve instead of a point. Ovate palæoliths often exhibit a "lateral platform," which, as has been shown, is probably the remains of either the dorsal or ventral surfaces of the rostro-carinate implement.

The chief points of this paper may be summarized as follows:

(1) The most primitive implement known is a tabular piece of flint with a hollow flaked out of one of its edges.

(2) The next stage is represented by a similar piece of tabular flint in which two opposing hollows have been fashioned in its edges. The flake areas of these two hollows have converted and formed a keel or gable, and have also inevitably produced a beak-like profile at the anterior region of the implement.

(3) This keel or gable and the beak-like profile are still more marked in the sub-Red Crag rostro-carinate, and in the implements of this type found in deposits intermediate in age between the sub-Crag detritus-bed and the river valley gravels, the flat ventral surface and the keel are gradually extended further back toward the posterior region.

(4) This extension of the keel culminates in the production of the early palæolithic side-chopper in which a cutting-edge extends continuously from the anterior to the posterior region.

(5) The triangular section of the pointed eolithic and rostro-carinate implements is transformed in the earliest palæoliths into a section which is roughly rhomboidal. This change was in all probability brought about by the removal by flaking of each side of the flat ventral surface of the rostro-carinate form, so that a thin cutting-edge was left.

(6) These earliest palæolithic implements often exhibit marked resemblance in their profile to the rostro-carinate form, and the remains of the dorsal or ventral surface of this latter type are often left at the butt-end of the implements. The remains of these surfaces have been called erroneously "lateral platforms."

(7) The most highly evolved palæoliths are those with straight symmetrical cutting edges, in which the rostro-carinate-like profile has almost disappeared.

It will thus be seen that the author is of the opinion that the most primitive "eolithic" implement is linked up with and related to the most symmetrical and perfect palæolith of the river-drift deposits. It is also his opinion, as a practical flaker of flint, that there is no other way of making the implements figured, except that described in this paper. But he does not claim infallibility, and it may be that some other investigator may be able to demonstrate a more accurate and better way.

Electricity in Medicine

Diathermy and Radiography

At a joint meeting of the Institution of Electrical Engineers and the Electrical Section of the Royal Society of Medicine, two papers relating to the application of electricity in medicine were read. One, by Mr. E. P. Cumberbatch, was on diathermy, or the use of the electrical current to raise the temperature of the body in the treatment of disease, while the other, by Dr. Robert Knox, discussed the limitations and possibilities of single-impulse, instantaneous radiography.

Mr. Cumberbatch explained that the most recent method of applying heat as a therapeutic agent is by means of an electric current of a special kind. When the current is passed through the body, part of the electrical energy is converted into heat in overcoming the resistance of the tissues, and there is, therefore, a rise of temperature in the parts it traverses. This method of applying heat to the body differs from all others in that it causes a rise of temperature of the deep-lying tissues as well as of those on the surface, whereas all other methods of applying heat raise the temperature of the skin only.

High-Frequency Currents

If a direct current is led through the skin by way of an electrode 1 square inch in area, a stinging pain is produced with a strength of 10 milliamperes, and the pain becomes unbearable with 15 milliamperes. To heat the skin appreciably a strength of 400 milliamperes would be required. An alternating current of low frequency would be equally unsuitable to produce diathermy, because it would cause violent and intolerable contraction of the muscles before it attained a density sufficient to develop heat. If, however, the frequency of the alternation is much increased the current loses its power to stimulate the excitable tissues. If it alternates 5,000 times per second the muscles contract only feebly and the stinging sensation is not felt. If the frequency of alternation is increased to 50,000 per second there is no perceptible stimulation of the tissues. The density of the current can now be increased to a value which could not be tolerated in the case of the direct or low-frequency alternating current, and only a feeble contraction of the muscles will be felt. If the frequency of the alternation is further increased to, say, 500,000 per second, the current will lose all power to stimulate the tissues whatever its strength or density. Such a current can be passed through the body and its density raised higher and higher and no sensation will be felt other than that of heat. The limit of toleration of such a current is determined only by the degree of heat.

The modern diathermy machine is designed to yield sustained high-frequency currents of 2½ to 3 amperes. The principle embodied in it is that of the d'Arsonval transformer. The condenser, of large capacity, is charged from the main by way of a stationary transformer which raises the voltage to 2,000, and the discharge is across two very narrow air-gaps placed in series. These lie between copper discs placed with their faces parallel and opposite to each other, the opposing faces, through which the sparks pass, being coated with silver. The width of each gap is ¼ mm. This arrangement gives uninterrupted chains of high-frequency oscillations in the solenoid. The current which passes to the patient is taken from a second solenoid, the extremities of which are connected to the electrodes. When the latter are placed on the body the voltage between them is probably less than 1,000. In most machines it is possible to connect one of the electrodes to some intermediate point along the secondary solenoid so that a lower voltage can be obtained, and further variation can be effected by altering the distance between the primary and secondary high-frequency coils.

Improvements in X-Ray Apparatus

After giving an account of the development of apparatus for dealing with single-impulse exposures in radiography, Dr. Knox enumerated some results which would be within reach if apparatus were available capable of giving a much larger output than those now in use.

The first desideratum is that the output should be powerful enough to give perfect radiographs without the use of intensifier screens, for good though are the results obtained with screens it would be a great help in technique if they could be dispensed with altogether. Most, if not all, of the single-impulse work of the present day is done in combination with the intensifier screen, which is always used in thoracic and abdominal work. Apparatus powerful enough to permit such work at a distance of 6 feet from the plate by the aid of screens would be powerful enough for work on other parts to be done at a distance of 2 feet without the screen. The great advantage over work now done by time exposure would be that no plates would be spoiled by movement of the patient. The solution of the problem he left to the electrical engineer, hoping to see realized in time the mammoth machine and the extraordinary results that will automatically follow from its adoption.—Engineering Supplement of the *London Times*.

Improving the Sugar Beet in Europe

The beet sugar industry was one which was developed to a very large extent in France in the period before the war, as will be remembered, but since that time the production has fallen off considerably, which accounts for the present scarcity of sugar in this country. The reason for this shortage is not only because the sugar beet regions are invaded or uncultivated, but is also due to the fact that the greater part of the seed was imported from other countries, and especially Germany. However, this state of affairs is being remedied, and on the other hand an effort is now made to make a selection of seed so as to increase the quality of the plant and the yield in sugar per acre. It takes, however, several years of repeated planting and selection on approved principles in order to obtain what are called "first quality" seed. These operations are carried on in special establishments, and now that the sum of $100,000 has been secured for this purpose, they will be effected on a large scale in an agricultural school with a personnel of both sexes. In Austria, Profs. Fallada and Griesenegger found that the production of beet seed is affected by the relation between lime and magnesia in the soil. One influence of lime is to make the plant take up less water in its growth, but it also neutralizes the effect of the magnesia which becomes harmful in certain cases. With a lime-magnesia ratio of 3 to 1, the yield in seed is nearly double what is found for a ratio of 1 to 3. They also observed that the seed can be treated to advantage by steeping in sulphuric acid for two hours, then dusting with lime and washing, and this produces a quicker growth and increases the size of the beet root, without lessening the proportion of sugar per pound of root.

Industrial Use of Grapevine Branches

The extensive vineyards in the south of France naturally furnish a large quantity of waste vine branches, and since the war this material is being used on an industrial scale, as it is found to be of value. For instance, the branches are employed in the paper industry, and measures are being taken to install the factories in this region so as to bring them nearer the source of supply and thus avoid expensive transportation. On the other hand, by distillation in a closed vessel, the branches furnish 39 per cent of carbon, 36 per cent diluted acids at 8.64 per cent value and 4 per cent tar, all these substances having a great commercial value at the present time. The carbon is made up into brickets, with the tar serving as an adhesive substance for this purpose, while the acids furnish methyl alcohol, acetic acid and acetone. The distilling process also furnishes illuminating gas, and such "wood gas" is now being used extensively on an industrial scale in France. It is estimated that 100 pounds of vine branches will produce 32 pounds of brickets. The vine branches contain a large amount of cellulose and starch and some attempts have been made to obtain sugars or saccharine products with a view of fermenting these and so producing alcohol. For instance M. Lindet succeeded in extracting from the dry vine branches as much as 37 per cent of different sugars, but he found that not more than half of these could be fermented and thus the operation would not have an industrial value. However, as researches of this kind are only beginning, perhaps other ways of utilizing this material may be found.

Toxin Production in the Soil by Growing Plants

In the *Annals of Botany* (Vol. XXXI, No. CXXII, pp. 181-187), Dr. Spencer Pickering gives a summary of his investigations of the effect of one plant on another growing near it. These experiments originated in 1895 in his well known observations on the effect of grass on fruit trees. Proceeding from this complex case to the simplest conditions, conclusive evidence of toxin production in the soil by the growing plant has now been obtained. The deleterious effect of one growing plant on another appears to be a general phenomenon. By means chiefly of pot experiments the following plants have been found susceptible to such influence: Apples, pears, plums, cherries, six kinds of forest trees, mustard, tobacco, tomatoes, barley, clover, and two varieties of grasses; while apple seedlings, mustard, tobacco, tomatoes, two varieties of clover, and sixteen varieties of grasses have been found capable of exercising toxic effects. In no case have negative results been obtained. The magnitude of the effect varies greatly, but the average effect in pot experiments is placed at a reduction of roughly one-half to two-thirds of the normal growth of the plants. The evidence that these detrimental effects are due to toxin production is regarded as conclusive. A plant affects its own kind just as much as any other kind, and hence it follows that the toxin formed by any individual plant will affect that individual itself. The practical bearing of these observations in various directions is discussed in the light of experimental results.—*Nature*.

A Study of the Proteins of Certain Insects*

With Reference to Their Value As Food for Poultry

By J. S. McHargue, Assistant Chemist, Laboratory of Chemical Research, Kentucky Agricultural Experiment Station[1]

In view of the present high cost of living, it is well to discuss and to consider seriously the utilization of every available source of sound animal protein, even though such proteins may have hitherto been looked upon as of not enough economical importance to warrant their utilization.

The object of this paper is to call attention to the efficiency of animal proteins as compared to vegetable proteins, and also to show by comparative analyses that two very common insects contain proteins which are very similar in character to those contained in the proteins which are very similar in character to those contained in the proteins of the higher animals which furnish a large part of our food supply.

Within recent years wonderful progress has been made in our knowledge of the character and properties of proteins. Formerly it was assumed that all proteins were of equal value in maintaining nitrogen equilibrium, regardless of whether such proteins were of animal or vegetable origin.

Thomas (2)[2], who was a pupil of Rubner, was the first to demonstrate experimentally the fact that animal proteins are much superior to vegetable proteins in maintaining nitrogen equilibrium in the animal body.

In order to demonstrate this fact, he performed the following classical experiment on his own body. In his diet he took large quantities of starch and sugar, and determined the minimum loss of protein under these conditions. He then took meat protein in an amount equivalent to this minimum quantity destroyed and found that if the food was divided into six portions, taken four hours apart, there was no loss of body protein. His experiments were carried still farther, and he showed the relative biological values of proteins of different origin. The following list shows the minimum amounts of different proteins required to protect body protein from loss:

	Gm.		Gm.
Meat protein	30	Bean protein	54
Milk protein	31	Bread protein	76
Rice protein	34	Indian corn protein	102
Potato protein	38		

He also states that there can be no doubt whatever as regards the superior value of the proteins of meat, fish, eggs and milk over those of bread, beans and Indian corn. The proteins of rice and potatoes hold an intermediate position.

The difference in the efficiency of animal versus vegetable proteins is further demonstrated by most wild animals in their natural selection of food. It is well known that all wild animals of the cat species live altogether on animal proteins. A recent investigation by the United States Biological Survey (1) in regard to the character of the food consumed by the wild birds of this country reveals the very interesting fact that an average analysis of the contents of the craws of 14 species of wild birds shows that approximately 50 per cent of all the food consumed in a year's time consisted of animal matter in the form of insects. If the fact that insects are only available for about six months of the year is taken into consideration, it is to be assumed that the diet of the wild birds consists almost entirely of animal protein during the season in which insects are available. It is also to be noted in this connection that the parent birds feed their young on a purely animal diet, thus exhibiting a wonderful instinct in the selection of a food that is most efficient for the rapid growth of their young. The avidity with which domestic fowls, when allowed to range, seek insect food is familiar to all, and it is a well-known fact that poultry thrive best when they have access to this kind of food.

After noting these phenomena in the selection of food by both wild and domesticated birds, it is only natural to inquire whether there is any chemical evidence as to the nature of the proteins contained in the various insects which will substantiate the birds' instinctive selection of this particular kind of food.

Through the recent researches of Osborne and Mendel (3-5) of Yale University and the Connecticut Experiment Station, it has been conclusively shown that the growth-promoting properties of certain proteins are due to the presence of that kind of protein which is capable of yielding upon hydrolysis the amino acids lysin, cystin, and tryptophane. Then, if the instinct of the bird in its selection of its food is a true guide, we would expect a protein analysis to show a considerable amount of these growth-promoting amino-acid groups present in this type of food.

In fact, protein determinations made by the writer on two common insects, the June bug (*Lachnosterna* sp.) and the grasshopper (*Melanoplus* spp.), showed such a large percentage of protein present in the dry state that a further study of the character of the proteins present, as revealed by the Van Slyke method for protein hydrolysis, was carried out. The results obtained are shown in Table I, under the proper headings, together with the results obtained by the same method of analysis on a very tender piece of cooked beef roast and the cooked tender white breast meat of a turkey. The specimens of beef roast and turkey were selected for comparison because they represent the more common higher types of animal proteins.

From the results obtained in the analysis of the water-free substance it is to be observed that the dried remains of grasshoppers contain a high percentage of valuable protein and also notable amounts of fat, phosphorus and potassium.

At different periods in the world's history this insect has occurred in such great numbers as to make it necessary to provide means for its immediate destruction. Whiting (8) describes a plague of locusts or grasshoppers which occurred in Palestine in the summer of 1915. He characterizes this plague as being one of the greatest of all grasshopper plagues on record, both in regard to numbers and to the amount of destruction done. The following paragraph is taken from his article (8, p. 513):

Quantities were now gathered by the poorer Bethlehemites. A few ate them roasted, describing the taste as delicious, especially the females full of eggs. Still the main reason for collecting them was in order to secure the small bonus offered by the local government of Bethlehem. Thus tons were destroyed, being buried alive till several ancient abandoned cisterns were filled, while in surrounding villages each family was required to produce a stipulated weight. Likewise in Jaffa they were destroyed by being thrown into the Mediterranean, and when washed ashore dead and dried on the beach, were collected and used as fuel in the public "Turkish baths" and ovens.

TABLE I.—*Percentage of amino-acid groups in animal proteins from different sources*

Group.	Grasshoppers.	June bugs.	Beef roast.	Turkey white meat.
Ammonia nitrogen	9.14	8.96	3.27	5.65
Melanin nitrogen	3.42	6.78	5.22	1.72
Arginin nitrogen	14.98	11.53	15.44	14.72
Histidin nitrogen	5.62	6.57	13.34	18.23
Cystin nitrogen	.23	.35	.49	.47
Lysin nitrogen	8.04	8.02	8.40	7.67
Amino nitrogen (in filtrate from bases)	52.87	50.80	40.89	42.41
Non-amino nitrogen (in filtrate from bases)	4.32	5.84	9.38	7.26
Total	98.62	98.85	96.43	98.13

As a whole, the results show considerable similarity for proteins varying so widely in their sources of origin. The chief points to be taken into consideration in an analysis of this kind, as showing important points in similarity or differences, are the four amino-acid groups, arginin, histidin, cystin and lysin. In the arginin determinations very closely agreeing results have been obtained on each of the different proteins analyzed. In the histidin determinations there is considerable variation. The result for this group in the first and second analyses is one-half of that in the third and one-third of that obtained in the fourth analysis. Figures for the cystin group show an increase of one-half in the second analysis over the first, and more than twice as much in the third and fourth analyses as in the first. The determinations in the lysin group show a remarkably close agreement in all the analyses. In the light of our present knowledge this is by far one of the most important groups contained in proteins, from the standpoint of growth and nutrition.

For the purpose of showing further points of interest in connection with the grasshopper the following work was carried out:

On September 23d, 1916, about 200 gm. of grasshoppers were caught, killed by means of potassium cyanid, dried at 100° C. until free from water, ground in a mortar, and placed in a ground-glass-stoppered bottle. With the exception of the opening of the bottle for weighing out portions for protein, fat and mineral-constituent determinations, the material has remained in the laboratory unmolested until the present time. A protein determination made on the same material after standing in the laboratory in this condition for seven months shows that there was no alteration in the protein content during this period of time, which demonstrates that the dry material can be kept indefinitely.

The following determinations were made on the moisture-free material:

	Per cent
Protein	75.28
Fat (ether extract)	7.21
Ash (crude)	5.61
Mineral constituents:	
Silica	.600
Iron oxid (Fe_2O_3)	.107
Manganese oxid (Mn_3O_4)	.008
Calcium oxid	.360
Magnesium oxid	.394
Potassium oxid	1.202
Sodium oxid	.335
Phosphorus pentoxid	1.190
Sulphur	.380
Carbon dioxid and unconsumed carbon, by difference	1.034
Total mineral constituents	5.610

While there has never been such a plague in this country as the one just described, grasshoppers have been known to occur in such numbers as to make it necessary to provide means for their control (6). Walton, (7) in a bulletin of the United States Department of Agriculture, cites instances where as many as three bushels of grasshoppers have been harvested per acre by means of a mechanical device known as the grasshopperdozer. It is quite probable that in many instances with suitable machinery for catching, drying, and grinding these insects they might afford a new source of a high-grade protein in all respects the equivalent of meat meal, which could be made to serve an economical use in the affairs of man, such as preparing balanced rations for swine, poultry and other live stock.

June bugs, while containing a slightly greater amount of protein than the grasshopper, and of equal value, could not be made an economical source of protein because of their limited number and the short time in which they are available.

From the data herein contained we may draw the following conclusions:

(1) That the instinct in wild and domesticated birds which guides them in their natural selection of the most efficient food is confirmed by the high lysin content found in the insects thus far examined.

(2) That grasshoppers deprived of their moisture contain a higher protein content than commercial meat meal, and in all probability could be made an efficient substitute therefor.

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[1]The writer begs to acknowledge his indebtedness to the late Dr. J. H. Kastle, who was much interested in nutrition problems and had suggested a study of the proteins of the grasshopper.

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Heat Treatment of Steel

EFFECT OF A MASS

Some experiments undertaken with the object of obtaining information in regard to the changes that take place in the interior of a mass of steel during heat treatment were described by Mr. E. F. Law before the Iron and Steel Institute.

He remarked that with the information now available it is possible to determine the theoretically correct heat treatment for any steel. The practical treatment of large masses of steel, however, presents many difficulties that do not exist in the case of small masses, and various questions at once arise, such as how long does it take for the mass to become uniformly heated in the furnace, to what depth does the effect of oil tempering extend, and to what depth is it possible effectively to harden steel by quenching in water?

In the experiments an ingot 25 inches square and 10 feet long, weighing nearly 10 tons, was cogged down to 18 inches square and cut into 18-inch lengths, thus giving a number of 18-inch cubes, each weighing about 14¼ hundredweight. Only those cubes representing the soundest part of the ingot were employed. These thermo-couples were inserted in each cube, in holes ½-inch in diameter, and carefully plugged in position with asbestos. One thermo-couple was placed in the center, one halfway between the center of the cube and the center of one side, and one ¾-inch deep in the center of one surface. These couples were inserted before the cube was placed in the furnace, and remained in position throughout the treatment, continuous records being taken. The cubes were placed in a gas-fired furnace at a temperature of 1,650 degrees F., and that temperature was maintained. The heat penetrated to their centers with remarkable rapidity. After 130 minutes the temperature at the center and halfway was almost the same, though at this point the absorption of heat due to the Ac change cause a greater lag at the center than elsewhere, and the two temperatures did not approach one another again until after another 70 minutes.

PHENOMENA OF COOLING

After about 4½ hours the cubes attained a uniform temperature throughout—practically that of the furnace. When this stage was reached one of the cubes was withdrawn and placed on knife edges to cool in the air. Cooling took place very slowly, and the evolution of heat was most marked in the center of the mass. A second cube was plunged in oil, and since a large volume of oil was used the cooling was rapid. In the center the evolution of heat at the Ar point was very noticeable, but in the halfway curve there was no indication of recalescence. A third cube was cooled by spraying water at a pressure of 10 pounds per square inch on the upper and lower faces. The cooling was more rapid than in oil. The curve for the center again showed an evolution of heat, and was not unlike the oil-hardening curve, though the rate of cooling through the lower ranges of temperature was more rapid. The halfway curve, however, was totally different. There was no sign of recalescence in the upper ranges, and the temperature fell evenly to about 450 degrees F., when there was a sudden acceleration in the rate of cooling, followed by an equally abrupt halt at about 250 degrees. The curve for the cooling of the outside of the cube showed somewhat similar features. In an experiment in which the cube was plunged into water at 55 degrees the cooling was somewhat more rapid, but the curves showed exactly the same characteristics.

The important difference between cooling in oil and in water was the almost sudden slowing up of the cooling with the former in the lower ranges of temperature as compared with the cooling in water. The time required for the center to cool from 1,650 degrees to 1,000 degrees was almost the same whether oil or water was used, but in cooling from 1,000 degrees to 600 degrees the cube in oil required twice the time, and from 600 degrees to 300 degrees nearly four times as long. The differences were even greater for the outside of the cube. Both in oil and water there was a period during which the metal in the center was cooling more rapidly than that midway between center and surface.

MECHANICAL TESTS

From each of the experimental cubes, after cooling, a section 1 in. thick was cut through the center, and from this section 13 test pieces were machined, so that mechanical tests could be made on metal representing the steel from the outside to the center of the cube. The 13 results from the air-cooled cube gave practically identical results. In the oil-quenched cube the breaking stress and yield were both raised, while the elongation was lowered, to almost the same extent in every test. In other words the effect of the oil-quenching was as apparent in the center as at the outside. The results obtained by water-quenching, however, showed very decided variation from surface to center, most marked in the case of the cube plunged in cold water.

The abrupt halt in the neighborhood of 250 degrees shown in the curves for the water-cooled samples was totally unexpected. The author gave reasons for supposing that it was not connected in any way with the water, but was due to some change in the steel itself, and he recalled some results obtained by previous investigators of the properties of iron and steel at low temperatures, which suggested the possibility of a transformation not hitherto recognized. On carrying out some experiments with 2-inch cubes, the break in the curve at 250 degrees was very noticeable with oil-hardening, whereas in the water-quenched cube no break in the curve was observed. Further, the latter cube was too hard to machine, and after grinding and polishing was found to possess a martensitic structure, while the oil-quenched cube was readily machined and possessed a pearlitic structure. Repeated experiments on quenching at different rates showed that whatever the rate of cooling through the higher ranges of temperature down to 572 degrees no appreciable hardening effect was obtained, and the hardening was effective only when the rapid cooling was continued through the lower ranges of temperature.—Engineering Supplement of the *London Times*.

Methods for Cutting Glass Discs

It is often desired to replace a glass disc which may have been broken, for instance on a barometer, a lantern, and the like. In practice it is a very difficult matter to cut out a disc directly by the use of a diamond run around a circular form such as a wood or metal disc, so that this method is not to be recommended. In certain cases where the edges of the glass are covered by the framing of the apparatus, a good way is to cut by a diamond on a series of straight lines all around the edge so as to make a many sided polygon, and this can be finished off by the use of flat pliers. A paper circle is pasted on as a guide for cutting. But where a clean edge is necessary, the following methods can be employed. It is an easy matter for the amateur to imitate the usual disc cutting device in which the diamond tool is held on the end of an arm and the glass plate rotates underneath it. All that is needed is a wood base, round or polygon, turning on a lower base about a pivot and holding the glass plate on top. A block is fixed on one side and on it is laid an arm having the glass cutter held upright so as to bear on the glass pane. The arm works in a screw slot or can be clamped down in any suitable way. This produces a very clean disc. When the circle is traced, draw several lines from the circle to edge of glass plate, so as to break off the extra glass in sections. Another method is to make up a compass like a bar drawing compass, glue a wood block (or cardboard) on the middle of the glass as a support, and use an arm having a pointed nail through one end as a pivot on the wood, and a glass cutter on the other end which bears down on the glass plate.

Peanut Oil Cake for Animal Food

It is recognized that peanut oil cake is an excellent food for stock, and during the war it is being introduced as food for horses. Although in general there are found no drawbacks in the use of this oil cake, certain precautions are necessary, as put in evidence by recent observations. In fact where horses were fed on the oil cake there appeared a prevalence of epizootics which is considered as due to the presence of toxic substances formed in the oil cake by the action of different spores. The French scientist, Dr. Beauverie observed that spores were always present in abundance in peanut cake, and these belong to quite a variety of species some of which will flourish at as low a temperature as 37 degrees C. Although many of these species are pathogenic, it appears that they become harmless when absorbed by the animal system, and the author believes that those of the spores which are dangerous owe their effect to the formation of toxines. While this may be true, another point to be considered is the production of ptomaines, for the albuminous substances of the peanut are especially rich in acids which can produce toxic bodies by decomposition. In any case the formation of toxines or ptomaines is greatly favored by heat, so that care should be taken in this regard in the storage of the oil cake, and on the other hand it is not good practice to allow it to stand in water for any length of time. The author even recommends soaking it in water only after boiling. On the whole, however, there seems to be no danger when the proper precautions are taken, and the appearance of toxic substance is to be taken as exceptional. Because of the great value of this substance for animal food, it cannot be too highly recommended for horses and stock. Hence, the above facts should be taken with due allowance and are to be considered rather as pointing out what precautions are to be taken in the storage and the use of peanut oil cake.

Product Possessing Rubber-like Properties

Casein or animal glue is digested with carbolic acid or acetic acid at a temperature not exceeding 180 degrees F. (82 degrees C.), until complete solution is effected. Mineral substances such as zinc oxide, zinc carbonate, or calcium hydroxide, and organic substances, such as glycerin, molten pitch, or solutions of resins or of rubber or celluloid may then be added, and the mixture is treated with formaldehyde, formic acid, or tannic acid with energetic mixing until the whole is converted into a tenacious rubber-like mass. If much pitch is used the product may be sufficiently insoluble without the subsequent treatment with formaldehyde or formic or tannic acid.—From an English Patent.

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